Vol. 53 No. 2

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October 1959

Quarterly

of the

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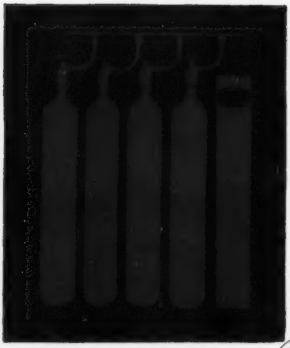

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Vol. 53 No. 2 October 1959

Quarterly

The Standard Technical Journal of Fire Protection for More Than Fifty Years

The NFPA is a non-profit technical and educational organization devoted to the reduction of loss of life and property by fire with a total membership of 17,000. The *Quarterly* is one of the publications regularly provided to members. Other membership publications include *Fire News*, *Advance Reports* to the Annual Meeting, a *Year Book*, and many leaflets, pamphlets and posters issued throughout the year on fire prevention and control. Six volumes of the National Fire Codes are available on an annual subscription basis, one volume free and others at reduced membership rates. For full details on available material ask for a free list of "Publications on Fire Prevention and Protection."

NFPA annual dues are $15.00 for Associate Membership of which $6.00 is for subscription to this Journal. National and regional societies or associations may apply for an organization membership for which annual dues are $100; such a membership entitles four individuals to receive the periodical membership publications.

Technical committees of the Association develop means to safeguard life and property through the publication of standards covering all phases of fire prevention and protection. Your membership in the Association affords an opportunity to keep abreast of these developments and, by being a member, you help support this humanitarian activity. Popular educational literature on fire safety is constantly being produced by the NFPA for distribution through its members to the general public.

National Fire Protection Association

International

60 Batterymarch Street Boston 10, Mass., U.S.A.

Entered as second-class matter December 15, 1928, at the Post Office at Boston, Mass., under act of March 3, 1879.

Printed in U.S.A.

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Quarterly

of the

NATIONAL FIRE PROTECTION ASSOCIATION

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Articles and accounts of fires appearing in the Quarterly are based on material forwarded to the Association. The Association, as a body, does not assume responsibility for the accuracy of the material printed herein.

This publication is indexed by Engineering Index, Inc.

STOP

Editorials

Foundation Support for Fire Research

The results of the Los Angeles school fire tests, to be published in full this month by NFPA, help very materially to round out our knowledge of how fires behave and what problems we face in protecting lives. Probably even more important are the additional test programs they suggest.

Continued experimentation of this sort would almost certainly lead us to the ultimate in the means to protect lives and property from destructive fire. But all proposals for experimentation face a very practical problem: how can the cost be underwritten?

A grant of funds by Educational Facilities Laboratories, Inc., a Ford Foundation project, was largely instrumental in getting the Los Angeles tests started. This $25,000 grant is the first and most sizeable contribution from a foundation to support either research into fire causes and control or fire safety education.

There are probably 10,000 foundations in the United States making funds available for a wide variety of projects in the public interest. Many are primarily concerned with the health and welfare of people. Surely the tens of thousands of people harmed by fire each year are a matter of concern, as is the welfare of the half-million homes annually visited by fire.

Educational Facilities Laboratories, Inc., has shown imaginative awareness of what is needed to perfect our means of fire waste control. It is to be hoped that other foundations will gain from this an understanding that destructive fire is a public enemy which deserves their attention.

The Broad Base of NFPA

If you asked someone what Mr. Fuad Ibrahim of Lebanon, Judge Francis Rocheleau of the Westbrook, Maine, Municipal Court, and Radio Announcer Robert Webster of Jamestown, N. Y., had in common, it might be difficult to get an answer. One might wonder also what the following industrial concerns have in common: American Motors, Arnold Bakers, Four Roses Distilling Company, Premier Peat Moss Producers, and Vitamin Dairy Goat Farms. About the only answer that could be made is the fact that each one of these is a new member of the National Fire Protection Association.

A review of new members in recent months provides a fascinating picture of the widespread appeal of our Association. The fire chief of the City of New York is a recent new member but so also is the fire chief of Terry Corners in New York State. The fire department of Pugwash, Nova Scotia, is a new member and so is the fire department of Ox

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Five firemen and one spectator were killed and 64 firemen injured when a ball-of-fire issued from a "skyrocketing" 21,000 gallon tank during a bulk plant fire in Kansas City, Kansas, on August 18, 1959. Two brick walls were knocked down by the flying tank which traveled 94 feet from its concrete supports landing 15 feet into the street where most of the firemen were on hose lines. The inadequately vented tank failed from built-up pressure after approximately 1½ hours fire exposure.

Bow, Saskatchewan. Consider colleges and universities, for instance. New memberships have come in recently from such widely diverse institutions of learning as the University of Arkansas, Brown University, Florida State University, Fordham, Texas Tech, University of Pittsburgh, and Smith College.

In recent months new memberships have come in from every one of our 50 states, every one of the ten provinces of Canada, and some 33 other countries including some countries that you might not think of as having people who would be interested in NFPA such as: Sumatra, Finland, Greece, Thailand, Pakistan, Israel, Iceland, Yugoslavia, Liberia and the Sudan. It is fascinating to note that in the same week that we received a membership from the National Aeronautic and Space Administration, we also received a membership from Moral Re-armament.

The observation is often made that fire affects every person and every property. This is so, of course, but we never realize it so clearly until we look over the terrific variety and scope of membership in our Association. NFPA today is truly not only international in character but a very real cross section of every kind of organization and individual. Therein lies our greatest strength.

Urgent Aviation Fire Research

Only rarely does the Association adopt a formal "Resolution" at its Annual Meetings, a policy designed to emphasize the importance of any so processed. This June, the NFPA unanimously passed a single resolution recommending that the newly created "Federal Aviation Agency immediately establish suitable facilities and organizations to initiate, conduct or monitor testing, and correlate *all* phases of research and development aimed at solving the many diverse problems associated with aviation fire hazards, including but not limited to those items detailed in NFPA Aviation Bulletin No. 230 entitled, Operation: Aviation Fire Research."

Acting on recommendation of the Executive Division of NFPA's Aviation Committee, the Association called attention to the fact that "the aviation industry has entered the jet age and in consequence is confronted with new aircraft, new engines, new fuels, new operating problems and new fire hazards." At the same time, the National Aeronautics and Space Administration has ceased all work in the field of aviation fire research and the Federal Aviation Agency has discontinued its aviation fire studies at the Technical Development Center (Indianapolis). While the latter has announced plans to resume such studies at their new National Aviation Facilities Experimental Center at Atlantic City, N. J., the loss of personnel skilled in this work and the need to reconstruct new physical facilities for a comparable program are staggering obstacles.

"Operation: Aviation Fire Research" outlines many, but not all, of the existing problems which need study. Copies of the *Bulletin* detailing the research needs are available from the NFPA (request AB 230, 50 cents a copy). The lack of aviation fire safety data is becoming more and more critical and the voids in our knowledge greatly handicap solving pressing problems which constitute major threats to life safety. The FAA is the only logical group to administer the research program since the industry itself would not adequately support the NFPA's 1957–58 appeal for a full time NFPA Aviation Field Service Engineer who might have coordinated and directed such full scale attack on a united, nonpartisan front.

Fatal LP-Gas Tank Truck Fire

By Clark F. Jones, NFPA Gases Field Engineer

Eleven spectators watching a burning LP-Gas tank truck lost their lives and ten others were injured when the cargo tank ruptured and rocketed up the road. The failure occurred 45 minutes after fire broke out at the rear of the filled 7000-gallon cargo tank.

At approximately 8:00 A.M., June 2, 1959, while the tank truck was stopped 60 feet behind a school bus, it was hit at the rear by another truck which was following and was unable to stop in time to avoid the collision. The accident occurred on U. S. Route 122, one mile west of Deer Lake, Pa., about 11 miles from Pottsville. Seconds after the collision, LP-Gas leaking from impact-damaged piping on the rear of the tank ignited, and flames enveloped the rear portion of the tank truck. (See Photo No. 1.)

Several Pennsylvania State Police cruiser cars were at the scene shortly after the accident and set up road blocks well removed from the accident. Volunteer fire departments from Deer Lake and Orwigsburg were called and arrived about 15 minutes after the fire broke out. No public or private water supply was available. Water from the booster tanks on the fire trucks was used with foam to protect the nearby wooden dwelling. (See Figure A.)

The fire burned intensely for about 45 minutes. Spectators reported the tank safety relief valves were operating during this period. However, suddenly the rear head of the tank failed. This sudden failure projected the remainder of the tank and truck up the road about 470 feet where the tank smashed into a stone retaining wall. Parts of the truck cab and running gear were torn loose in flight. (See Photo No. 2.)

After hitting the wall (see Photo No. 3), the tank tumbled and rolled over

Pennsylvania State Police

Photo No. 1. It was raining on June 2 when an amateur photographer snapped this picture of the burning LP-Gas tank truck on U. S. Route 122 near Pottsville, Pa. LP-Gas leaking from damaged piping ignited immediately. The loaded school bus that had stopped on the highway was driven to a safe location before this photo was taken.

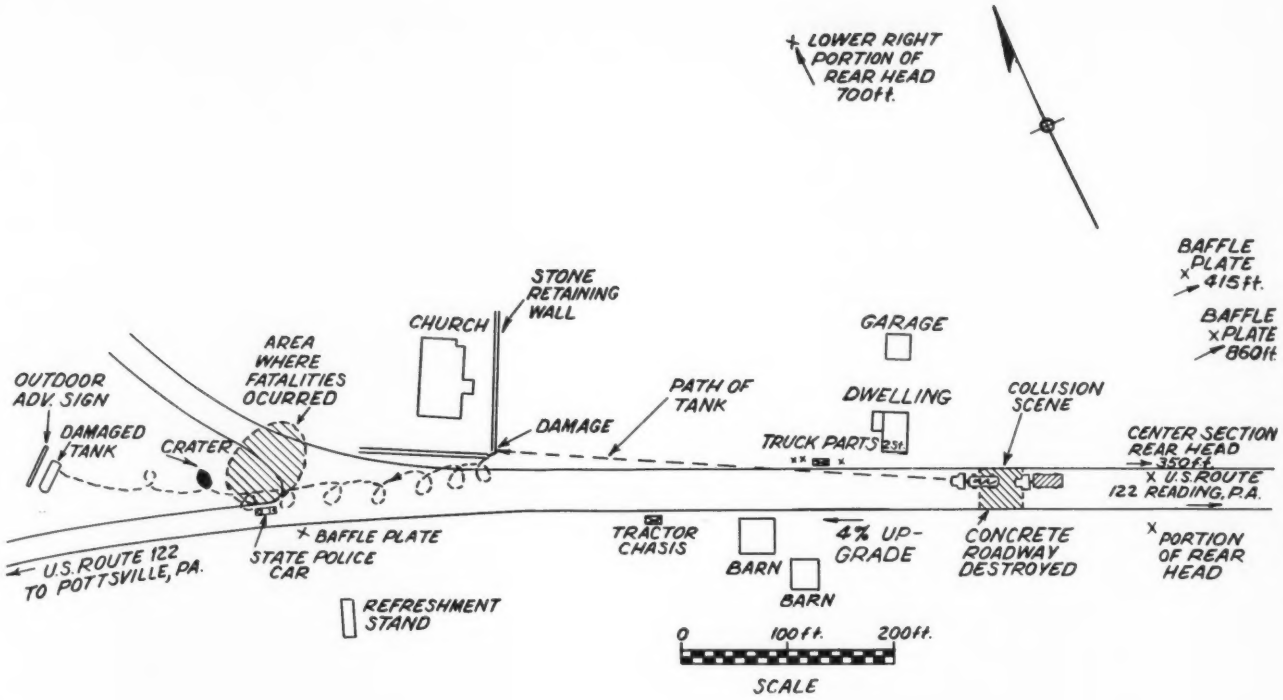


Figure A. Sketch of the scene of the LP-Gas tank truck accident near Deer Lake, Pennsylvania. Note that all of the victims were about 700 feet from the collision scene. Baffle plates traveled 860 feet and the tank shell came to rest 900 feet away.

Pennsylvania State Police

Photo No. 2. Some of the debris torn from the tank truck before hitting the stone wall is shown. The dwelling, 90 feet from the burning tank truck, was protected by fire department hose streams.

Pennsylvania State Police

Photo No. 3. The tank struck the stone retaining wall shown in the approximate center of the picture, before careening along the road and through a group of spectators.

the highway, dug into the ground beyond the road intersection, and finally came to rest about 900 feet from the point of original collision. (See Photo No. 4.) Most of the victims of this tragedy were grouped near the road intersection 700–800 feet west of the spot of collision and were killed by the flying debris and the tank. No one near the original point of collision was killed, although several firemen were burned when the rear head failed and there was the sudden release of LP-Gas which burned with a torch-like flame.

Pennsylvania State Police

Photo No. 4. Final resting place of the tank after traveling 900 feet. A baffle plate is in foreground.

Fire damaged telephone and electric poles, wires, and cables alongside the road. Radiant heat effects were noticed on trees and shrubbery as far as 550 feet distant. The concrete roadway was spalled for a considerable area. Spalling was about a foot deep under the rear end of the tank truck.

The accident occurred on a rainy day. After the collision, the vehicles came to rest with between 20 and 30 feet of space between them. There are conflicting statements as to why there was so much space between the vehicles. The contents of the trailer, consisting of miscellaneous office supplies, etc., were destroyed by fire. (See Photo No. 5.)

Pennsylvania State Police

Photo No. 5. View of tractor-trailer truck that struck the rear of the LP-Gas tank truck. During the fire, more than 20 feet separated the two vehicles. The contents of the tractor-trailer truck were destroyed by fire.

How It Happened

The collision damaged the LP-Gas piping mounted in a cabinet on the rear of the tank and the impact may also have been a factor in the ultimate failure of the tank; note the dent shown by the arrow in Photo No. 6.

It was quite possible that the original LP-Gas release was from damage to the 3-inch liquid withdrawal connection at the bottom of the tank. (See Photo No. 7.) Undoubtedly, this release of gas was below the minimum rate of flow which would cause the excess flow valve to operate; and it would, therefore, not be expected to close. The leak continued, and in a few seconds the LP-Gas ignited, possibly at the motor of the tractor-trailer which had struck the tanker. Observers stated that a few seconds elapsed before a big flash occurred, enveloping the rear of the LP-Gas tank truck.

The drivers of the vehicles were not seriously hurt. The tractor-trailer driver was helped to safety by following autoists. The LP-Gas tank truck driver got out of his vehicle and asked motorists to get help. Ironically, he was later injured by flying debris.

Pennsylvania State Police

Photo No. 6. Segments of rear head of tank recovered following the failure. Dent indicated by arrow may have been caused by collision. Twisted piece at top center of photo (left center of head) showed evidence of exposure to severe heat.

Apparently, when the fire departments arrived on the scene they were told by the tank truck driver not to put out the fire; that it was all right to let the gas burn since the tank was equipped with safety relief valves. This was sound advice as far as it went. Unfortunately, the fire fighters were not told what might happen to the shell of the tank if the fire was allowed to continue to expose the shell until the contents had boiled away. Without guidance on the need for keeping the tank shell cool, fire fighters used the limited amount of water available to protect the nearby dwelling.

Description of Tank Truck

The LP-Gas tank was designed for 250 psi working pressure. It was built in 1957 in accordance with the 1956 ASME Unfired Pressure Vessel Code —

Pennsylvania State Police

Photo No. 7. Damaged excess flow valve and shut-off valve equipped with extension operating lever. These valves were installed in withdrawal line.

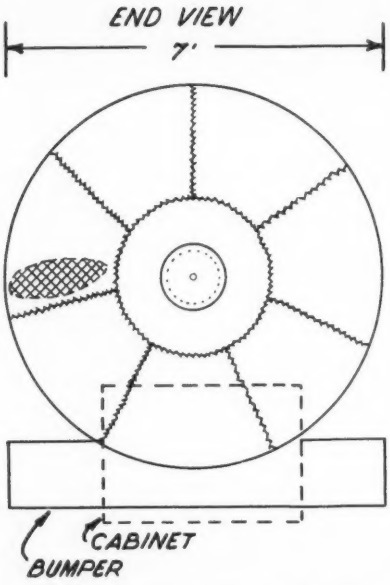


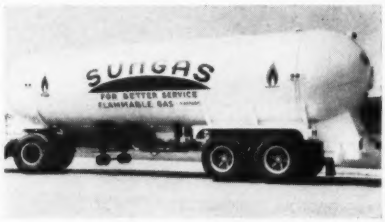
Figure B. Sketch of rear head. Cross-hatched area showed evidence of severe heating.

Case 1204–3. It was fully radiographed and stress relieved. The tank was 7 feet in diameter and 33 feet, 2 inches, long. It had a water capacity of 8,555 gallons. The tank was constructed of a low carbon, tempered alloy steel having 105,000 psi tensile strength, shell thickness 0.419 inches, head-plate thickness 0.250 inches. The heads were designed as a hemisphere of "modified orange peel" construction as illustrated in Figure B. The tank was mounted on a semi-trailer, without framing, as is shown in Photo No. 8. Insofar as can be determined, the arrangement of the tank truck piping was as illustrated in Figure C.

Tank Failure

Impact damage to the 3-inch withdrawal line in the bottom of the tank shell near the rear may have released liquid product at any of the joints or at the tank connection itself. The ensuing fire undoubtedly quickly destroyed the rubber tires on the trailer unit, as well as spalled the concrete highway; this allowed the rear end of the tank truck to settle slightly. During the fire some protection from flame was afforded the lower part of the rear head by the metal cabinet housing the piping connections and by the fender construction over the rear wheels of the trailer unit.

As the fire continued to burn the quantity of LP-Gas within the tank was gradually reduced by leakage from the damaged piping and vapor discharge through the safety relief devices. This lowered the liquid level in the tank and exposed more "unwetted" tank surface to intense flame and heat until the upper left hand portion (See Figure B) of the rear head was weakened sufficiently to fail. Examination of the metal made it evident that the rear head was exposed to severe heating at the location shown on Figure B (see the forged shape of one of the recovered pieces of the rear head shown in Photo No. 6; the distorted shape is probably due to excessive heating).



Pennsylvania State Police

Photo No. 8. This tank truck is the one that was involved in the accident. Note the rear cabinet which housed the external piping.

Pieces of the rear tank head seem to indicate a pressure failure due to weakening of the metal from exposure to severe fire. Pieces of the rear head were blown considerable distances as shown in Figure A.

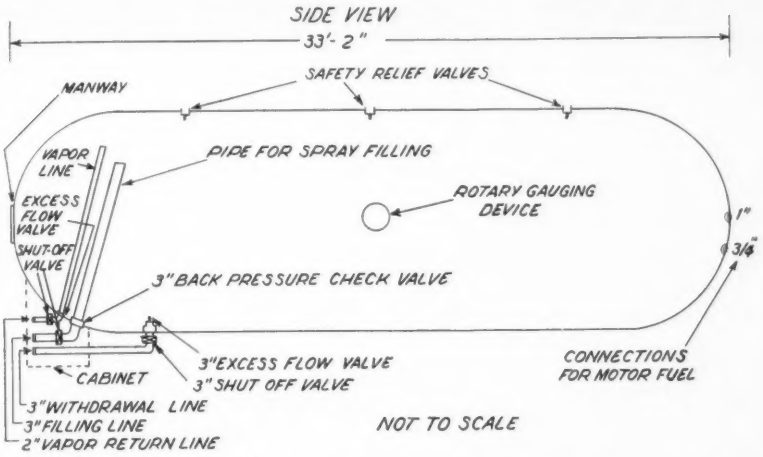


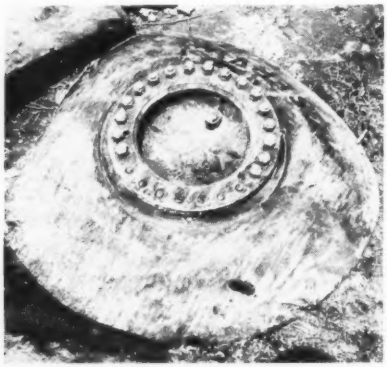
Figure C. Side view sketch of tank, showing openings, safety relief valves, arrangement of piping and equipment at the rear end. Principal damage from collision is thought to have occurred at connection of withdrawal line to tank.

Pennsylvania State Police

Photo Nos. 9 and 10. Close-ups of severely heated portions of rear head shown in upper part of Photo No. 6.

Photo Nos. 9 and 10 are close-up views of the left-hand portion of a section of the rear head shown at the top of Photo 6. Evidence of severe heating of this portion of the head can be noted. Points of failure in the head were not confined to the "heat-affected zone" from welding but tears were noted in the parent metal.

It would be difficult to determine whether in the initial impact a portion of the rear head was struck and weakened sufficiently to start failure or whether the burning LP-Gas enveloping the rear head was the prime factor. A synthetic rubber gasket which reportedly had been used at the "manway" (center of rear head) was destroyed early in the fire, allowing LP-Gas to leak and burn around this area. This concentrated heat surely adversely affected this portion of the tank. A spectator, who tried to pick up the center portion of the rear head after it arced 350 feet behind the scene of the accident, stated it was "red hot" when he touched it. (Photo No. 11.)



Pennsylvania State Police

Photo No. 11. Upside down view of center section of rear head. Section shown is approximately 4 feet in diameter. Destruction of a combustible gasket beneath the bolted manway plate allowed LP-Gas to leak and burn in this area.

Lessons to Be Learned

This tragic accident caused many authorities to be concerned about the transportation of LP-Gas over the road. Within the past year a number of other accidents involving highway transportation of LP-Gas have occurred, for instance, one in Los Angeles, California, on November 14, 1958; one in St. Paul, Minnesota, April 29, 1959; one in Napa, California, May 8, 1959; and one in Portland, Oregon, on February 27, 1959. This was the most serious highway accident but was followed on June 28, 1959, by a railroad accident in Meldrim, Georgia, where 23 persons lost their lives.* This Pennsylvania accident has been the first serious accident involving a transport using this type of alloy steel as far as can be determined. After a careful review of NFPA Standard No. 58, "Standard for the Storage and Handling of Liquefied Petroleum Gas," the following suggestions are submitted:

a. The requirements in NFPA No. 58 for the protection of tank trucks from physical damage were written when all trucks were built with frames. In many cases today, tanks are mounted on frameless units in which the tank acts as the frame. It seems appropriate that bumper construction and support requirements be studied in light of the changed circumstances.

b. All connections from the tank, except safety relief valve and gauging connections, should be provided with automatic, internal, quick-closing valves, kept closed except during delivery.

c. Prohibit all pipe connections in rear heads, as heavier metal in shell walls provides a more secure and stable point for connection. Prohibit the installation of piping toward the rear in such a way that it will be vulnerable to damage from rear end collision.

*See August 1959 issue of FIRE NEWS.

d. Gaskets should be of noncombustible material.

e. It may be desirable to consider a shear-action or weakness ring in the piping connections adjacent to the tank to be certain no undue strain is put on the tank and that piping will break off cleanly on impact.

f. This incident illustrated the need for continued efforts to train people how to handle serious emergencies when leaking LP-Gas is on fire. The following advice on methods of handling such emergencies is extracted from the article "How to Handle LP-Gas Vehicle Incidents" published in the August, 1959, issue of FIREMEN magazine.*

1. *Do not extinguish* unless leakage can be stopped, except under certain conditions.

2. If the escaping gas is on fire, immediately apply large quantities of water as quickly as possible to all surfaces exposed to heat, with approach to the tank being made from the sides. Concentrate on piping and metal surfaces of vessel or adjoining vessels, equipment or combustible surfaces exposed to flame or intense radiant heat.

3. Consult driver of vehicle or plant operating personnel (as the case may be) regarding possibilities of shutting off fuel supply. Stopping the flow of gas should be the first consideration.

4. If the only valve which can be used to stop the flow of fuel is involved in fire, consider the possibility of effecting shut-off by protecting firemen with water fog streams and protective clothing while they are closing the valve. Proceed slowly to avoid any flash-backs or trapping firemen in the flames.

5. The controlled burning of escaping LP-Gas (which cannot be shut off by closing a valve) is a commonly accepted fire-fighting practice. The application of sufficient water to keep the shell of the vessel and piping cool will allow the fire to consume the product in the tank without danger of causing failure.

6. Dry chemical portable extinguishers are effective for extinguishing small LP-Gas fires. Extinguishing agent should be directed toward point of vapor discharge. Carbon dioxide may also be used.

7. When sufficient water is not available to keep the tank cool, some warning of increased pressure may be noted from the increase in volume of fire or noise level. This should serve as a signal to consider the withdrawal of all men to a safe area.

8. Failure of LP-Gas tanks usually occurs *only* when some portion of the metal surface in the vapor space of the vessel becomes overheated, softens and weakens to the point that it will not contain the pressure of the product. In the absence of sufficient water to keep the metal surface cool where it is exposed to direct flame impingement or extreme radiant heat, there is danger of the tank rupturing and creating a condition which is commonly described as an explosion.

9. Shooting holes in an LP-Gas tank that is involved in fire does *not* serve any useful purpose and should *not* be permitted.

10. Ordinarily, no attempt should be made to move any tank involved in a fire as usually little would be gained in reducing the hazard. However, if specific conditions develop to where it is considered desirable to move the tank, it should not be moved in anything but an upright position. Never drag in a manner which might further damage valves or piping. Any attempt to turn the tank upright to remove to some remote location or to facilitate product withdrawal should be done carefully to avoid damage to valves and piping.

In case flame impinges on the tanks, in the absence of cooling by hose streams there is nothing in present tank design to prevent pressure rupture or explosion at a time when the contents have evaporated and the tank shell is weakened by heat.

* This article summarizes several LP-Gas tank truck accidents and discusses procedures in the event of fire or serious leakage without fire. Reprints available from NFPA, 10 cents each.

Acknowledgments

This report records the personal observations of the author who visited the scene of the fire and explosion at the request of Fire Marshal L. L. Priar, Pennsylvania State Police, Bureau of Fire Protection.

We acknowledge with sincere thanks the invaluable help given by Colonel Frank G. McCartney, Commissioner, Pennsylvania State Police, and countless others who have assisted in the preparation of this report.

Unfortunately, reports have not been received from several metallurgists who examined samples of the tank metal.

Air Agitation for Control of Tank Fires*

The now disbanded Committee on Special Extinguishing Methods requested the NFPA Committee on Foam to study the use of air agitation as a means of combating oil tank fires. This statement by the Committee on Foam was prepared as a result of this request and is published for the guidance of those interested

The following statement represents the position of the Committee on Foam in regard to the air agitation method of combating oil tank fires:

"Fires in oil storage tanks, where the temperature of the lower portion of the oil in the tank is lower than the flash point of the product, may be extinguished by the air agitation method. The basic theory of ignition is that the temperature of the oil surface must be above the flash point in order for the oil to ignite. In practice, it will be the unusual incident where a tank fire occurs when the oil surface temperature is above the flash point and the main oil body temperature is below the flash point.

"One such unusual situation might occur in a test fire where low flash oil is used to prime the surface, thus permitting the surface to be ignited while the main body temperature remains below the flash point. Ignition of an obsolete type wooden roof of a tank containing high flash oil may establish similar conditions where air agitation might successfully extinguish the fire. Such situations, however, are rare. Air agitation could *not* be relied upon as an acceptable method of extinguishment by itself for *typical* oil tank fires.

"Under certain circumstances where delays occur in assembling foam extinguishment equipment, air agitation might be a useful *supplemental* fire fighting tool. For a limited period of time after a tank fire has started, agitation may bring about a material reduction in flame intensity for fuels of low volatility. Under these limited conditions this method could provide for faster control of the fire, reduce the amount of foam required and reduce the amount of oil burned and possible tank damage. It could reduce the amount of cooling water needed on adjacent tanks and permit closer and safer approach with portable equipment. In the early stages of a tank fire involving some crude oils, air agitation might minimize risk of a slopover when foam is first applied. These benefits are limited to the period before fire and agitation raise the temperature of the main body of the oil to that temperature that would exist at the surface under free burning.

"In summary, air agitation generally cannot be considered as a basic method for combating oil tank fires. Under some circumstances, however, it may be a useful supplemental fire fighting aid.

"In view of the limitations of the technique of the air agitation method it does not seem desirable at this time for the NFPA to originate standards of installation for this method of extinguishment."

*References to previous QUARTERLY articles: July 1952 (Volume 46, No. 1), pages 83–92; July 1954 (Volume 48, No. 1), pages 61–68 and July 1956 (Volume 50, No. 1) page 25.

Wood Shingles—1959

By Rexford Wilson, Engineer
NFPA Fire Record Department

The increasingly widespread use of wood shingles as a roof covering in Southern California and in certain areas of Texas has caused considerable concern on the part of many fire service officials. Memories of the devastating wood-shingle conflagrations early in the century prompted the NFPA to send a representative to the areas most heavily involved to determine the actual hazard at the present time and the probable hazard in the foreseeable future. This

The help so willingly given by architects, builders, building officials, fire department personnel and others is gratefully acknowledged. NFPA Staff Photos except the picture on the next page.

Homes nestled in the fast burning brush of Southern California create the greatest conflagration hazard noted during this survey. Picture a single wood-shingle roof fire on a windy day with flaming brands dropping into the dry brush and on other wood-shingle roofs.

is a report of the findings of the study made during the last week of July and the first two weeks of August, 1959. While Southern California and Texas were the areas covered in this survey they are not the only areas thus plagued.

Reminiscence

There are two characteristics of roofing in general which create a fire problem. One is the ease with which it will ignite from lightweight fire brands and the other is the hazard of brands from burning roofing that are large enough to ignite other combustibles (wood-shingle roofs, brush, lumber and so on). *Only* the wood-shingle and the wood-shake roof have both the easy ignition *and* dangerous flaming brand characteristics. Some poor grades of asphalt roofing can be ignited, but asphalt roofing of any type does not give off dangerous flaming brands. Flaming brands from wood-shingle or shake roofs will result from a fire starting on the roof or from a fire starting in a building which spreads to the roof.

Historical Fires Show Wood-Shingle Hazard

Since 1900 there have been 129 sweeping-fire type conflagrations. Sixty-three have occurred partly or totally due to the presence of wood-shingle roofs. Of the remaining 66, 62 were caused by all other factors combined, in four cases no data was available as to the factors responsible for the conflagrations.

The significance of the wood-shingle roof in a conflagration condition is apparent when the severity of the forementioned conflagrations is studied. In 100 of the 129 conflagrations mentioned above, the number of buildings destroyed is known. A study of these 100 fires reveals the following interesting facts.

The largest *non-wood-shingle type conflagration* occurred on May 6, 1950, in Rimouski, Quebec, where 346 buildings were leveled by a fire starting in a lumberyard. A total of 2,815 buildings were destroyed in the 46 conflagrations of this type for an average of 61 buildings per fire.

Berkeley, California, September 17, 1923. This $6,000,000 loss was the result of a wind-driven brush fire which ignited a great number of wood-shingle roofs in the residential area of the city. Note that while the evidence indicates close spacing between dwellings on the same side of the street, the fire jumped reasonably adequate street widths to engulf the entire section shown. All these conditions still exist in Southern California today.

WOOD-SHINGLE CONFLAGRATIONS IN TEXAS AND CALIFORNIA SINCE 1900

NOTE: Parentheses show factors responsible for conflagrations.

Date	Location	Property Destroyed	Reported Loss
April 3, 1909	Fort Worth, Texas (wood-shingle roofs, wind velocity in excess of 30 mph)	255 Buildings (1 killed)	$ 610,340
April 3, 1909	Dallas, Texas (wood-shingle roofs, wind velocity in excess of 30 mph, fire department at other fires)	65 Buildings	215,000
Feb. 21, 1912	Houston, Texas (wood-shingle roofs, inadequate water distribution system, wind in excess of 30 mph)	140 Buildings	2,500,000
March 21, 1916	Paris, Texas (wood-shingle roofs, high wind, lack of exposure protection)	1440 Buildings	11,000,000
March 14, 1920	Grandview, Texas (wood-shingle roofs, inadequate water distribution, high wind)	136 Buildings	2,000,000
Sept. 17, 1923	Berkeley, Calif. (wood-shingle roofs, high wind, brush fire entered city)	640 Buildings	6,000,000
July 2, 1929	Mill Valley, Calif. (wood-shingle roofs, inadequate water distribution)	130 Buildings	1,500,000
July 28, 1934	Dorris, Calif. (wood-shingle roofs)	Factory, 61 Buildings	276,416

The largest *wood-shingle type conflagration* occurred on April 12, 1908, in Chelsea, Mass., when 3,500 buildings were leveled. A total of 20,428 buildings were destroyed in the 54 conflagrations of this type, an average of 378 buildings per fire (32 buildings more than in the largest non-wood-shingle conflagration and roughly six times the average building loss per fire.

The tremendous devastation caused by these wood-shingle conflagrations prompted cities all over the United States to action. Six hundred and forty-eight of the larger cities took positive steps to eliminate the hazard by the adoption of the NFPA Suggested Fire-Resistive Roofing Ordinance* or similar legislation. The West Coast states, where those interested in profit from wood-shingle roofs evidently outvoiced those interested in public safety, were notable exceptions.† While wood shingles have been dying out as a roof covering material during the last twenty years over most of the rest of the country, recently in California and in Texas the use of wood shingles for this purpose has been increasing.

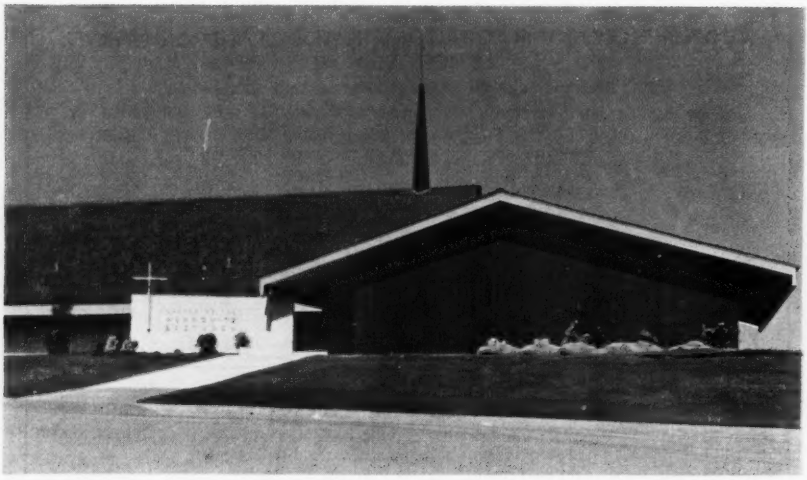
The Present Problem

With the effect of wood shingles on the conflagration situation so clearly visible, what then is the reason for its continued use as a roof covering? What is obscuring this danger from the vision of the public and the officials on whom the public relies?

Three factors seem to be the major blocks to effective wood-shingle control. One factor is the rampant "red herrings" that exist about whether *this* piece of wood will burn as readily as *that* piece of wood, since *that* piece is cut differently, or is slightly larger. Another factor is the seemingly slow burning characteristics of new wood covered roofs. The final factor is the misleadingly low individual fire experience in present-day wood-shingle roof areas.

*Copies available from NFPA.

†San Francisco is the only city on the West Coast which has recognized the wood-shingle hazard through prohibitive legislation.



Many different kinds of buildings were found with large area wood-shingle or shake roofs, including churches (such as shown above), shopping centers, post offices, motels, etc.

This picture shows about 75 per cent of the approximately 200 homes going into a 40-acre development. Picture the ease of fire spread when a wind is blowing across these wood-shingle roofs. In a few years these roofs will probably stretch on to the horizon.

The narrow spacing often found between homes is clearly demonstrated here. A strong breeze and delayed fire detection are all that would be needed to lose these two homes and the rest of a half-block of similarly spaced and constructed homes. Note that the typical variation in wall finish makes wall-to-wall fire spread much less likely than roof-to-roof spread.

Obscurity No. 1: The Shingle vs. the Shake

Great confusion about the burning characteristics of the various types of wood-shingle roofing was found during this study. Whether the shingle should be cut edge grain or cross grain; whether it should be white pine, red cedar or redwood; whether it should be clear heartwood or not; and whether it should be ⅜ inch thick (5 by 2 shingle) or over 1 inch thick (shake) were interesting topics of conversation. Undoubtedly these factors greatly affect the life of the shingle from a weather standpoint, but unfortunately they make little difference from a fire standpoint.

Anyone who has watched large pieces of burning lumber flying around during a lumberyard fire knows that the difference in thickness between a shingle and a shake, and differences in type of wood, will make only minor differences in their ability to ignite and become airborne during a conflagration.

From reports of those who have made large scale fire tests under adverse weather conditions and from previously published fire test results* the following statement can be made:

> The style of cut, type of wood and slight variations in thickness of the shingle and shake have very little to do with the fire behavior of a wood-shingle or shake roof under the adverse weather conditions that can be expected during a conflagration. A WOOD-SHINGLE ROOF IS A WOOD-SHINGLE ROOF.

*The report of tests on all types of roof combustibility which were conducted by a Committee of the Dominion Fire Prevention Association was printed in the July 1926 NFPA QUARTERLY, pages 64 to 82.

House building in Southern California and Texas is very rapid. This scene shows three homes under construction — one with the slotted roof sheathing exposed, one with asphalt impregnated paper laid over the sheathing, and the last, with the wood-shingle roof just completed.

These wood shingles are the best grade, all clear, all heartwood, edge grain, 5 by 2, red-cedar shingles. The thinness of each of these shingles is shown by the book of common matches in the middle of the second stack. This pile of shingles is for the roof of just one house such as shown above and indicates the amount of fuel available in such a roof covering.

The swing away from single-story dwellings has started. These 1½-story buildings show the return to the steeper roof. Note the typical across-the-street spacing which will aid fire fighting in normal fires, but also note the narrow house-to-house spacing.

Obscurity No. 2: New vs. Old Wood-Shingle Roofs

Another point of confusion is that new wood-shingle roofs appear slow to ignite compared with older wood-shingle roofs. New wood shingles are less susceptible to ignition from either direct radiated heat or from flying brands than older wood shingles which have been subjected to alternate wetting and drying, loss of trapped moisture in the wood and other weather influences.

Newer shingles will lose most of their entrapped moisture during the first extended low humidity period. Thereafter their moisture content will be substantially determined by that of the air. These Southern California and Texas areas are subject to extended low humidity periods.

Obscurity No. 3: Low Roof Fire Experience

It is certainly true that the individual roof fire experience of recent years in the wood-shingle roof areas has been favorable. There have been few fires involving wood shingles. This, however, has led to the mistaken impression that wood shingles as they are made today do not constitute the hazard of yesterday. This does not appear to be the case at all.

The lack of fires is the direct result of known physical factors: (1) No outdoor burning in many areas; (2) Heating is with gas or electricity with few fireplace fires or solid fuel furnaces; (3) Good water supplies; (4) Plenty of fast mobile radio-equipped pieces of fire apparatus that usually can be called on to chase sparks from a minor residential wood-shingle roof fire (second alarm companies are sometimes called as spark chasers); (5) Buildings are usually low (12–14 ft.) which enables homeowners to protect themselves with garden hose equipment; (6) The pitch of roofs is usually low which will slow down flame spread somewhat.

All of the above factors combine to cause: (1) a scarcity of ignition sources and (2) most favorable handling of a fire once it does start.

Note the better than average distance between roofs in this development of custom-built homes. While predominantly wood-shingle and wood-shake roofed, there are also asphalt and gravel, rock, and fire retardant roofs in this area. Some homeowners choose to stain their shingles green or dark red. Sixty-four of the eighty-two roofs above are wood shingle.

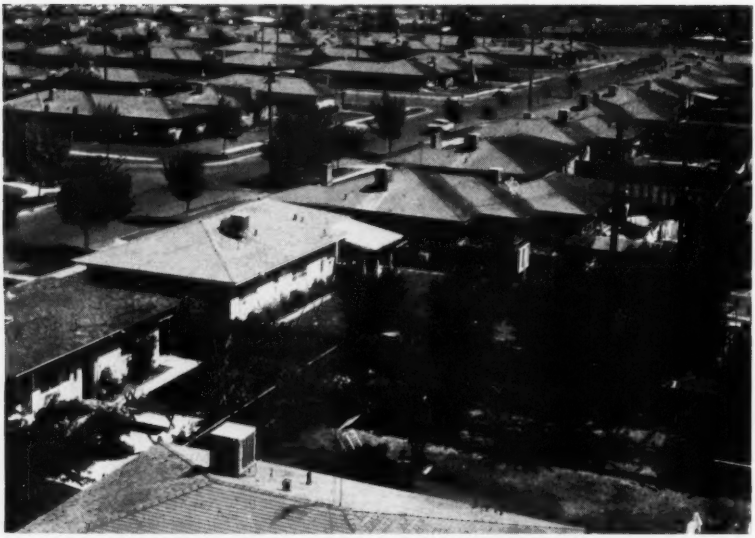
The Conflagration Factors

Physical factors known to contribute to conflagrations, however, are unchanged from those of yesteryear; many of them exist in the present-day wood-shingle hazard areas. Winds over 30 miles per hour, low humidities for extended periods, and expanses of wood-shingle roofs were the major physical factors that contributed to the previous conflagrations. These same factors exist in both Southern California and parts of Texas today. Add to this the normal possibilities of delayed discovery or alarm, the fact that the first-due engine companies may be at another fire (as happened at the recent Laurel Canyon fire in Los Angeles) and that the low pitch roofs will tend to hold flaming brands and the possibilities for conflagrations get even worse.

While it is true that ignition of wood roofs is rarer than in previous days, fires do occur and it is folly to assume they will not occur under the unfavorable conditions that breed conflagrations.

There are three situations where the combustibility of wood-shingle and shake roofs will play a major part in the conflagration picture. In decreasing order of probability, they are fires: (1) in the brush and canyon country, (2) in the residential areas and (3) during a major disaster.

A view down Willow Glen Road in Laurel Canyon shows two of the 38 homes destroyed in the explosively spreading brush fire of July 10, 1959. The two homes still standing were roofed with white asphalt fire retardant roofing.



Most of the dwellings in this five-year old development have wood-shingle roofs presenting a definite conflagration possibility under the dry, windy weather conditions experienced annually in these areas.

Dangers in the Brush Country

The separation of the house from the surrounding brush is the major factor in the survival of a home in a brush area fire. This fact was reproven recently during the Laurel Canyon fire in Los Angeles.

Homes with many different types of roofs were destroyed due to their proximity to the brush. It is interesting to note, however, that while some homes with composition roofs were saved, there were *no* wood-shingle roofed homes remaining within the burned area.

The problem of the exposure of the brush to the home, however, is only half of the problem. The flaming brands from a wood-shingle roof fire in this area could easily start a myriad of small fires in the brush, and if the wind were blowing at the time, a major fire could easily develop.

With the extremely dry year that has already started in Southern California, there is little doubt that there will be other major brush fires this year. With the increased numbers of homes constructed in the mountainous surroundings of Los Angeles during the last few years, there is little doubt that homes will be involved in such fires. As many of these homes have wood-shingle and shake roofs, it is possible that by the time this article is read, even more wood-shingle roofed homes in these mountain areas will have been destroyed by fire.

Dangers in the Residential Areas

The Uniform Building Code or some form of it is in force in most of the towns visited. This Code as used on the West Coast often calls for only 3 to 5 feet clearance from the property line; thus, many of the development homes have only 6 feet between neighboring homes. With roof overhangs of from 18 inches to 30 inches, there is some-

times as little as 12 inches between the roofs of adjoining homes. When all these homes have wood-shingle roofs, there is, in effect, one fire area a house wide and a block long.

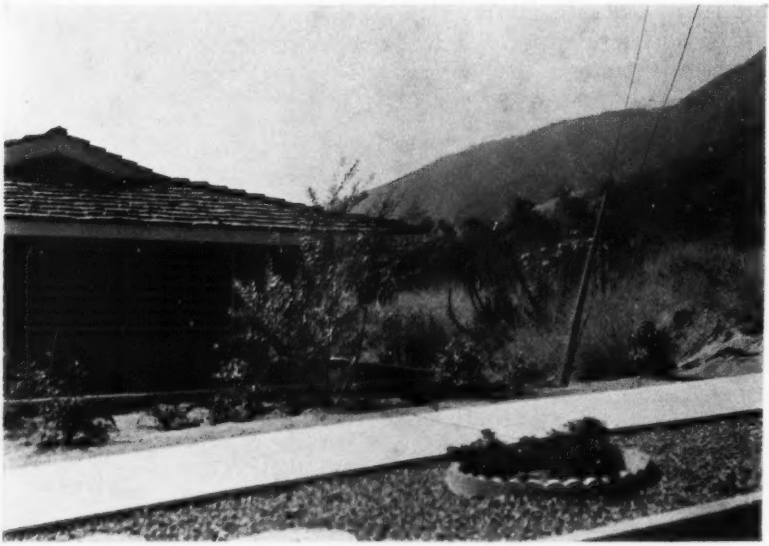
The house separation across the street in both California and Texas is excellent with 80 to 150 feet being common. The spacing to the rear of the homes is usually adequate. These front and back distances, while good protection from direct fire exposure, are relatively insignificant in cases where burning brands are flying thousands of feet.

One typical area measured approximately 5 square miles and contained approximately 17,000 homes, all but a fraction of one per cent with wood-shingle roofs. There is little doubt here that under unfavorable wind conditions a great number of homes could be destroyed by a flying brand fire.

In another area a large wood-shingle roofed development had no hydrant protection whatsoever. While home spacing in this development is superior to that mentioned above, the chances of a conflagration are increased by the lack of an adequate water supply for fire department operations.

It is interesting to note that most deteriorated wood-shingle roofs are being replaced with new fire retardant roofs. This replacement helps eliminate older wood-shingle sections from cities and makes old wood-shingle roof conflagration areas self-cleansing. The cost of new wood shingles and of relaying such a roof covering is higher than the application of an asphalt fire retardant roof over the old wood shingles. The latter process is common in the areas surveyed because of its economy.

Fire retardant roofing is normally used to replace deteriorated wood shingles in the California and Texas areas. The cost of replacing with wood shingles seems to be too high.



The rustic effect of wood shakes sought by many home owners is increased by nestling the homes as close to the natural surroundings as possible. A major brush fire roaring along this mountain range could quickly ignite this roof and involve many other dwellings in this same development which is partly shown on page 106.

Dangers from a Major Disaster

It is a rare spot in the areas visited that does not have to be artificially watered some portion of the year; therefore, (1) the water consumption is high (700 gallons per person per day in one town visited) and (2) the individual citizen has a fair-sized water distribution system of his own. This means that the public can either help or handicap the fire service during a major fire.

In one fire a few years ago the fire chief asked for public cooperation in the conservation of water and found that on the day of the fire 20,000,000 fewer gallons of water (about 18 per cent of the daily water consumption of the city) were used than either the day before or the day after the fire. At the Laurel Canyon fire the system worked the other way; frightened people in surrounding canyons used 90 gallons of water for each 10 used by the fire service.

To supply all this water is quite a job. Much of it must be piped through long mountain aqueducts to the area of use. About 20 per cent of the Los Angeles water supply is piped this way at the present time, and in the future this percentage will increase. A severe earthquake could easily end this supply and cause a severe water shortage. This would greatly increase the already unfavorable conflagration hazard.

Conclusion

The present situation indicates that the possibilities for wood-shingle roof conflagrations exist. A wrong combination of circumstances is all that is needed.

If wood shingles continue to be used at the rate which they have enjoyed over the last five to ten years, then the certainty of a major wood-shingle roof conflagration in the areas studied will be assured.

Christmas Tree Hazards and Treatments

By George H. Tryon, III

Assistant Technical Secretary, National Fire Protection Association

This article deals with the fire hazards of Christmas trees and current data on the treatment of Christmas trees to decrease their combustibility. It revises a statement on the same subject published in the October 1953 QUARTERLY.

Position of NFPA

The position of the National Fire Protection Association on this matter should first be explained. The NFPA continues to be very much concerned about the special fire hazards of Christmas trees. It does not, however, have testing facilities to evaluate the effectiveness of the various treatments proposed for reducing the combustibility of Christmas trees. It has also proved to be a thorny problem to establish conclusive testing procedures for use by local fire departments and similar agencies which would include all variables — different types of trees, cut at various times, subject to different weather and humidity conditions, and treated with varied skill by spraying or dipping.

Because Christmas trees are generally cut long in advance of use, and therefore become readily combustible, the National Fire Protection Association recommends that:

"To reduce the hazard, the tree trunk should be sawed off at an angle, at least one inch above the original cut end, and kept standing in water during the entire period the tree is in the house. Water should be added at intervals to the jar or tub in which the tree stands to keep the water level always above the cut."

The principle of setting a tree in water is that the tree will absorb the liquid and keep it from drying out for a longer period of time than would otherwise be the case. The limitations are that the age of the tree affects its absorption abilities, and after the tree is cut the "sap stream" is broken, interfering with the movement of sap or water from the base of the trunk to the branch tips.

Attempts to add fire-retarding chemicals to the water have not proved successful. The Forest Products Labora-

Wide World

On December 23, 1956, seven patients in the Doctors Memorial Hospital in Minneapolis died when a short circuit in the wiring of a tree lighting set ignited this Christmas tree. Starting in the lobby, flames and smoke penetrated a central stairway on which fire doors had been blocked open.

Charles Meehan, Photographer

Two families were made homeless in Ashley, Pa., on Dec. 30, 1950, when this dwelling was destroyed following ignition of a Christmas tree by a defective lighting set.

tory reports that experiments with this technique actually increase combustibility and cause the needles to discolor and fall.

Aside from setting the tree in water, every precaution should be taken to eliminate potential ignition sources. This subject is discussed on pages 119–122.

Agriculture Department Statement

The U. S. Department of Agriculture in its Technical Note No. 250 "Treating Spruce and Balsam Fir Christmas Trees to Reduce Fire Hazard" recommends the water treatment and the procurement of fresh trees as follows:

"1. Obtain a tree that has been cut as recently as possible.

"2. Cut off the end of the trunk diagonally at least 1 inch above the original cut end. Stand the tree at once in a container of water and keep the water level above the cut surface during the entire time that the tree is in the house. If the tree is not to be set up for several days, it should meanwhile be kept standing in water in a cool place."

If started in time, this procedure is recommended not only to prevent the needles from drying out and becoming extremely combustible, but also to keep them fresh and green. The U.S.D.A. also recommends, based on work done since issuance of the Technical Note (1952), disposal of the tree promptly when it no longer absorbs water freely.

Commercial Testing Laboratories

In recent years, a number of firms have been manufacturing and advertising Christmas tree flameproofing compounds for *external* application. A few of these have been tested by commercial

testing laboratories but the lack of a standard testing procedure has restricted the value of the results obtained. Without a standard method of test, results cannot be realistically evaluated or effectively duplicated.

California State Fire Marshal Tests

The State Fire Marshal of California has available for those interested an "Approved List of Flame-Retardant Application Concerns, Fabrics, Materials and Chemicals." This list includes flame retardants for Christmas trees for external application and may be obtained from the Printing Division, Documents Section, Sacramento 14, California, for 50 cents.

Stand it in water immediately!

The California program involves applying the chemical to fresh green branches of Douglas fir, approximately three feet long. The combustibility test is performed at the completion of a 30-day aging period. The tests require that there shall be no spread of flame from the area in contact with the test flame nor any after-flame longer than 10 seconds. The treated branch shall also not lose its needles more readily nor turn brown to a greater extent than those of the untreated branch similarly aged. California is the only state where, to our knowledge, there is such a program.

By issuing this list of Christmas tree flame-retardants it is not the intent of the California State Fire Marshal's Office that the products be used by private citizens treating trees in their homes. Proper equipment for the application of Christmas tree coatings is vital; something like a hand spray gun would not be suitable. The important fact is that any Christmas tree coating must be fairly viscous in order to be effective. Since coatings of adequate thickness cannot be built up with thin solutions, it is mandatory that efficient power spray equipment be used. Dipping is also effective but would be practical only for large-scale operations.

Keep it watered when you bring it in the house!

The best chemicals will not be effective if not properly applied.

Generally in California, flameproofing is done only by registered applicators under the existing state laws. This is particularly true for flameproofing of textiles, drapes, curtains, decorative materials, etc. The State Fire Marshal has found it impractical to apply this rule for Christmas trees because of the short duration of the business. Fire

departments do check the local Christmas tree applicators in their areas to make certain that they use approved chemicals and that the trees are properly treated.

In connection with flameproofing of Christmas trees with *external* coatings such as those approved by the California Fire Marshal, it is important to realize that *fresh*, green Christmas trees are inherently quite flame resistant because of their relatively high moisture content. When such a tree is treated, an immediate test of the still-fresh tree will not reveal whether or not the treatment is effective since the tree would not burn in the first place. Trees are a hazard only after they become somewhat dry, and the effectiveness of any treatment cannot be ascertained until the tree is in this condition. Of course, the majority of trees delivered to metropolitan cities for use by homeowners have to be cut a month or more before being sold and thus are normally pretty dry even before being placed in the home.

Don't place near open fireplace — always use a screen!

Underwriters' Laboratories

Tests have been conducted by Underwriters' Laboratories, Inc., but no flameproofing treatments have been listed by this organization as yet. Their tests have consisted of determining the fire exposure needed to consume full-sized untreated green trees and then exposing other treated full-sized green trees within 48 hours, 30 days and 60 days after treatment. The trees tested have included four species of evergreens from each of the three major areas where Christmas trees are cut in this country. The trees were exposed to a fire started in a pound of shredded newsprint distributed annularly at the base of the tree. Underwriters' Laboratories feel that these tests on full-sized treated trees are very desirable since small-scale tests on branches often give inconclusive or misleading results.

No treatments yet tested on full-sized trees have convinced Underwriters' Laboratories that any relaxation of the usual precautions to prevent the ignition of Christmas trees is justified. Some treatments are not only ineffective in preventing the spread of flame but also liberate volumes of smoke and fumes beyond those normally given off by a burning untreated tree.

Don't use frayed or worn wiring!

Underwriters' Laboratories are of the opinion that setting Christmas trees in

Associated Press

Prompt fire control minimized the seriousness of the dollar loss in this Detroit fire to $800.00 but to one child the loss was obviously tragic.

plain water, as has been advocated by the NFPA for many years, may reduce the ease of ignition of the tree to some extent, depending on the circumstances. Even with this precaution, however, Christmas trees still present a very severe potential fire hazard. They look forward to the development of treatments which will materially reduce the hazard, but, in the meantime, they urge that the limitations of present flameproofing treatments be recognized and all possible precautions be taken to prevent tree ignition.

Absorption vs. External Applications

It must be concluded that the absorption method using fire-retardant chemicals is generally unsatisfactory and is markedly influenced by many variable factors such as the species and size of the trees and the length of time elapsed since being cut. The use of plain water has advantages but cannot be relied upon to maintain a tree in fresh condition.

The compounds for external application discussed above are trade secrets of the manufacturers and we do not know their exact composition. The U. S. Department of Agriculture Technical Note 250, mentioned previously, gives three formulas for decorative coating "for those willing to undertake the extra trouble and expense." They are:

Formula I

(Produces a shiny transparent colorless coating)

Ingredient	Parts by Volume
Sodium silicate (water glass)	9
Water, containing a wetting agent such as Dreft, Vel or Breeze (about 1 teaspoon per quart).	1

Formula II

(Produces a cream-colored coating. May be tinted with suitable dyes)

Ingredient	Parts by Weight
Sodium silicate (water glass)	31
China clay	41
Water, containing a wetting agent (about 1 teaspoon per quart)	28

Formula III

(Produces a frosty white coating. May be tinted with suitable dyes)

Ingredient	Parts by Weight
Sodium alginate	1.0
Monoammonium phosphate	25.0
China clay	4.0
Water	70.0

Heat the required amount of water to approximately 180°F. Add the sodium alginate and stir until a uniform gel is obtained. Add the monoammonium phosphate, heating gently and stirring occasionally until the chemical has dissolved. Finally, add the china clay, wet with a few drops of water to make a thick paste, and stir until it is uniformly distributed throughout the gel.

It might be possible to make up one of these solutions in the home but no guarantee can be given that it will be satisfactory or that it will not result in

Acme Photo

A Christmas tree fire in a dwelling in Hyndman, Pa., on Christmas Day 1949 started this raging fire which ultimately destroyed 25 homes and apartments and 12 stores with the loss estimated at $500,000. One person was killed and 10 injured.

needle falling. A heavy coating is necessary and two or more applications may be required. It is extremely difficult to get an even coating over all sides and edges of the branches and needles, and if spray application is attempted, it may be necessary to thin the solution, in which case more applications are necessary.

Discoloration of the green and premature falling of the needles occur with certain chemical applications. Similarly there is no sure way of predicting how an application will behave on the different species of trees and how effective an application is when applied to trees cut at different times prior to the flameproofing treatments.

The use of various colors of water-based paints on Christmas trees by dipping or spraying may also reduce the combustibility but likewise no guarantee can be offered as to the fire-retardant effectiveness of such treatments.

Conclusion

It can be seen from the above discussion that, generally speaking, the problem is an unsolved one. California reports it has not had any fires in trees that were treated as it specifies and that thousands of such trees are treated each year. Some local fire departments in other parts of the country are offering to spray or dip trees with one or more of the solutions mentioned herein and we have had reports that their programs have been successful. How much of this success is due to the treatment that the trees receive and how much to the psychological awareness of the fire hazard of the tree by the public who secures this service cannot be estimated.

Regardless of any treatment provided for the tree, the NFPA recommends the following procedures to prevent premature dryout of Christmas trees and to minimize the ignition sources which frequently exist:

The Tree

1. Cut a growing tree or purchase one which shows it has not been allowed to dry out by prolonged storage. When too dry, tree branches are brittle and shed needles easily. (Test flexibility of small branches and retention of needles.)

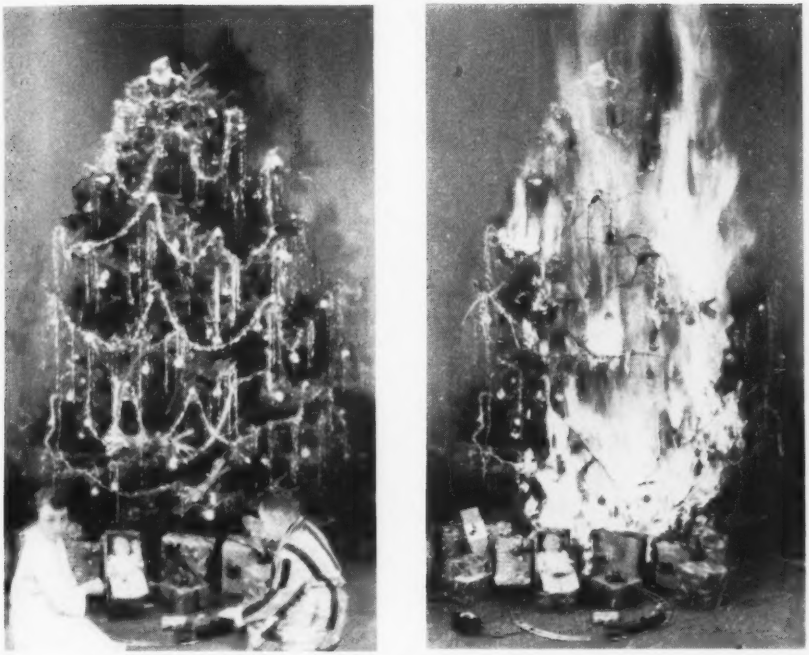
2. Stand the tree in water or snow outdoors until you are ready to use it indoors. Bring the tree indoors just before Christmas and remove it as soon as it has served its purpose.

3. The larger the tree, the greater the hazard, so do not get one any larger than you need.

4. Just before setting up the tree, saw off the trunk at an angle at least one inch above the original cut.

TESTING CHRISTMAS TREE FOR FRESHNESS

TEST BY:	TREE IS FRESH IF:
Bouncing butt hard on ground.	Needles do not shower down.
Pulling at needles at end of branch.	Needles have good resistance.
Rubbing finger across stump.	Stump is sticky with resin.



A test fire which demonstrated the combustibility of a Christmas tree under simulated home-use conditions.

5. Support the tree well. There are on the market some excellent stands which not only have a receptacle for water, but which are sturdy, have a broad base, and incorporate clamps for anchoring the tree.

6. Keep the tree away from sources of heat (fireplaces, radiators, etc.) and so that, standing or fallen, it could not block the way out of the room or out of the house in case of fire.

7. Place the freshly cut tree trunk in water and keep level of water above the cut the entire time the tree is indoors. (Check the water level at least once a day for absorption and evaporation.)

Lighting

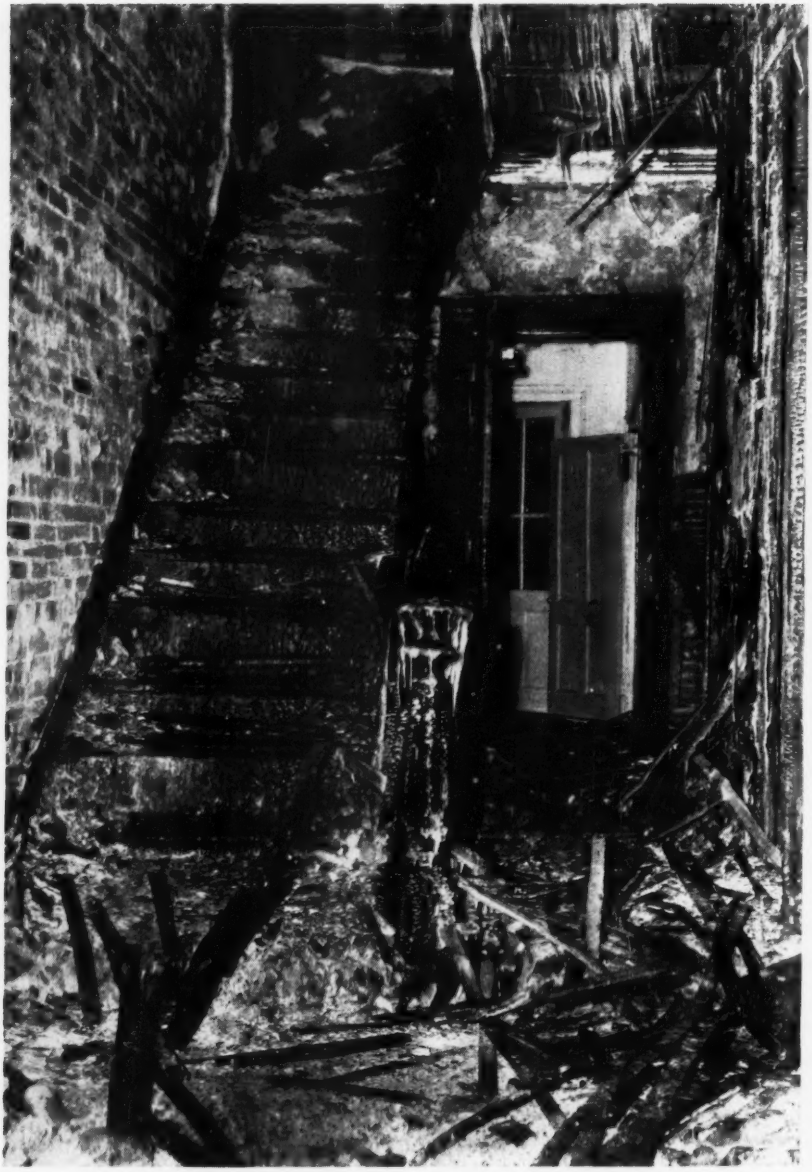
8. Do not use wax candles on the tree or nearby where there is any chance for an open flame to contact the tree or combustibles piled beneath the tree.

9. Use only electric lighting sets that bear the UL (Underwriters' Laboratories, Inc.) label. Be cautious about buying imported lighting sets lacking UL labels; some foreign tree light bulbs have shown imperfections which can cause them to shatter and expose the hot filament.

10. Check lighting sets each year *before* using, for frayed wires, loose connections, and broken sockets.

11. Be sure the fuse of the electric circuit serving the tree is not over 15 amperes. Cord sets with a fuse in the plug, bearing a UL label, are available.

12. If any extensive holiday wiring is indicated call a competent electrician;



Christmas Eve in 1945 was a tragic one at the Niles Street Convalescent Hospital in Hartford, Conn. Seventeen patients and 2 attendants lost their lives when combustible cotton around the base of a Christmas tree ignited and fire spread rapidly up this open stairway.

International News Photo

The Niles Street Convalescent Home in Hartford, Conn., the night of December 24, 1959. Substandard electrical wiring and combustible Christmas decorations caused the tragedy.

do not try to do it yourself, unless you are so qualified.

13. Make certain that all tree lighting is turned off before retiring or leaving the house.

Decorations and Wrappings

14. Do not let combustible Christmas wrappings accumulate in the home; place them in a metal-covered trash barrel or burn them in an incinerator at a safe location as soon as possible.

15. Use noncombustible material (metal, glass, asbestos, etc.) to decorate the home for Christmas wherever possible. When you must use combustible materials, be sure they are "flameproofed," particularly if they are to be placed near the tree.

16. Untreated cotton batting, polystyrene foam, paper and certain cloth costuming will ignite quite easily and burn with great intensity unless they are "flameproofed." Santa Claus's whiskers have caused Christmas tragedies; be sure they are "flameproofed."

17. Do not use the fireplace to burn Christmas wrappings and decorations. Guard against flying sparks from a fireplace with a substantial screen.

Gifts

18. Do not buy pyroxylin plastic dolls or toys. Toys operated by alcohol, kerosene or gasoline are especially dangerous; they may upset and set fire to children's clothing, the tree or the house itself.

19. Look for the Underwriters' Laboratories label when buying electrical toys. This means they have been tested

for fire and shock hazards and may be considered safe if properly maintained.

20. Do not set up electric trains, self-propelled toys or toys fueled with flammable liquids under a Christmas tree where they might be responsible for upsetting the tree or igniting it.

21. Film projectors (toy or adult) should be labeled by the UL and only safety film (acetate stock) should be used.

In General

22. Do not allow smoking near the tree, amid decorations or wrappings. Have plenty of safe ash trays around and use them.

23. Keep matches, candles, etc. away from young children not trained in their hazards.

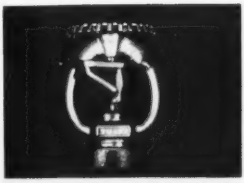
24. Plan on what *you* must do *if* fire breaks out.

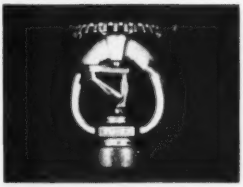
25. Have operative water-type fire extinguishers, buckets of water or a garden hose connected to a faucet, within reach of the tree. *But remember, unless you are sure you can put a fire out immediately call your fire department at once.*

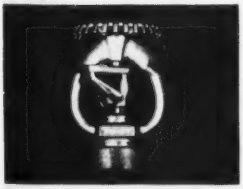
Water and the Automatic Sprinkler System

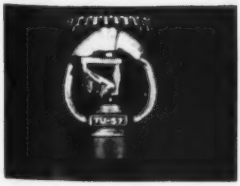
By Frank J. Fee, Jr.

President, The Reliable Automatic Sprinkler Co., Inc.
Member, Society of Fire Protection Engineers



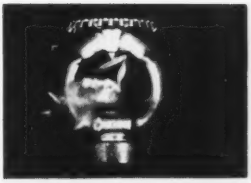


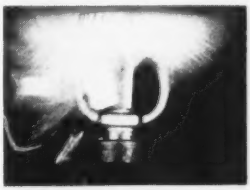


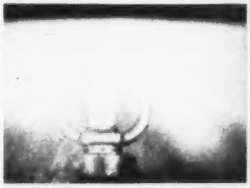


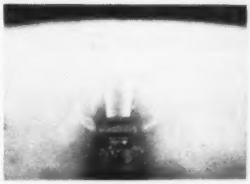
The performance records of automatic sprinklers have been assembled by the NFPA ever since 1897. The latest record,* issued in 1955, tells us that satisfactory performance for the period 1925 to 1954 was 96.2 per cent based on a total of 58,961 fires. Furthermore, the record shows that 37.5 per cent of these fires were extinguished or held in check by one sprinkler, 54.3 per cent by two or less sprinklers, 73.4 per cent by five or less sprinklers, 83.9 per cent by 10 or less sprinklers, and 92 per cent by 25 or less sprinklers.

In an explanatory NFPA statement regarding these tables, it is pointed out that "since numerous fires, extinguished by one or two sprinklers, with a slight loss, are not reported, the record represents only a fraction of the total number of fires in sprinklered properties. If it were possible to include a complete record, the efficiency of sprinkler performance shown by these tables would even more nearly approach 100 per cent." Also, the percentage figures for fires









Based on an address by the author at the 63rd NFPA Annual Meeting held June 1–5 at Atlantic City, N. J.

*See April 1955 QUARTERLY. The Record is printed in separate pamphlet form, identified as Q48–12, available at 50 cents per copy.

extinguished or held in check by one or two sprinklers would be substantially higher.

This record certainly substantiates the value of automatic sprinklers as a way to detect a fire automatically in its incipient stage, to transmit an alarm, and to extinguish or hold the fire in check pending the arrival of fire fighters.

As indicated by the record of 96.2 per cent satisfactory performance, sprinklers are doing an outstanding job of holding down fire losses. However, in 3.8 per cent of the cases (2,255 fires) reported to the NFPA, sprinkler performance was unsatisfactory. Why was it that these systems did not do the job expected of them? In the NFPA Sprinkler Tables reasons for unsatisfactory performance fall into 13 categories. In only two of these, namely "slow operation" and "defective dry pipe valve" (total of 90 fires), did the system itself perform unsatisfactorily. "Closed sprinkler valves" was the most frequent cause (808 fires) of failure, "hazard of occupancy too severe for the system as installed" was second, and "inadequate water supplies" was third. In this article let us take a close look at this last item.

Any sprinkler system to be effective needs a water supply sufficient in volume and pressure to permit the system to extinguish the fire or hold it in check. The NFPA studies show that in 205 fires inadequate water supplies were directly responsible for the failure of the systems to achieve the usual effective results. This represents about 9 per cent of the total number of unsatisfactory sprinkler performance fires catalogued by the NFPA.

Analyzing these 205 fires, we find that insufficient water or low water pressure from *public supplies* accounted for 104 of the failures; insufficient water or low water pressure from *private supplies* accounted for 16; insufficient water for both sprinklers and hose streams caused 38 unsatisfactory performances; gravity tanks being empty were responsible for 22 large fires; pump failures or pumps not started accounted for 10; mains broken accounted for 8; and miscellaneous reasons accounted for the last 7 of these unsatisfactory performances.

Just about all of these fires involved manufacturing and storage facilities, with manufacturing plants heavily predominating. Quite obviously, in the cases of gravity tanks being empty, pump failures or pumps not started, and mains broken, the water supply would be inadequate, if not nonexistent. Improper maintenance shows its ugly head in such cases. But what about insufficient water or low water pressures from public and private supplies and insufficient water for both sprinklers and hose streams? Combined they represent 75 per cent of all the unsatisfactory performances in this category with deficient public supplies way out in front. It is apparent that these inadequacies existed either at the time the sprinkler system was installed, became existent sometime thereafter, or were the result of a combination of both these circumstances.

Adequacy of Water Supplies

Let us examine the first possibility — an inadequate water supply at the time the sprinkler system is installed. This could come about by an improper determination of the needs for the hazard involved or by a proper determination that had been compromised.

The determination of what is an adequate water supply is principally a matter of judgment based on experience obtained from both actual fire results and laboratory fire tests. The former is the most extensive, but in recent years the new test facilities of Factory Mutual

Laboratories and Underwriters' Laboratories have made possible definite water supply information for such hazards as rubber tire storage, barreled whiskey storage and information on high piled storage, particularly in connection with the use of wooden pallets.

Section 3 of the NFPA Standard for the Installation of Sprinkler Systems (No. 13) provides us with the criteria for water supplies. It is based on the experience gained over the years that automatic sprinklers have been in service. Just in 1958, it was substantially revised to be more definitive so that greater uniformity of judgment would prevail.

The problem would be a simple one if we could know for certain the number of sprinklers that would operate in each instance should fire strike. Fire, however, is unpredictable. It may start most anywhere and many times starts in the least expected places. The number of sprinklers it may open depends on such factors as the kind of occupancy, the combustibility of contents, the areas shielded from proper distribution of water, the height of stock piles, type of ceiling construction, ceiling heights, unprotected vertical openings, undesirable draft conditions, and the size of undivided building areas. Another factor most worthy of mention is the kind of housekeeping. Fire reports on large loss fires contain a liberal sprinkling of such phrases as "an accumulation of fine combustible dust on floors, ceilings, and structural members"; "accumulated paint spray residue on floors"; "inadequate ventilation for flammable vapors"; etc.

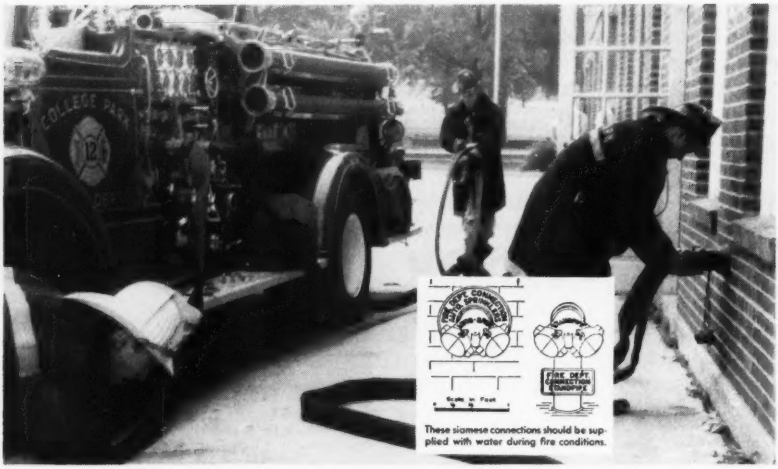
The final decision on the water supply requirements rests with the authority having jurisdiction as stated in Section 3 of NFPA No. 13. Many would like to find a way to eliminate the judgment factor, but there seems to be little hope for such an accomplishment. It would be very difficult, if not impossible, to set down in rule form how much water in volume and pressure is needed for every conceivable condition. Section 3 does provide ranges and by adhering to its recommendations, individual judgments have much greater uniformity and the risk of overlooking one or more important factors, which would contribute to the number of sprinklers expected to be opened, is minimized.

Proper use of a siamese fire department connection to a sprinkler system.

Hazard of Compromise

Being human, all of us are capable of making mistakes. The individual who never makes a mistake is the individual who never does anything. An error in undervaluating water supply requirements is one thing, but to evaluate the need correctly and then compromise it, is something else.

Such a compromise may come about by an owner in an excess of "smart buying" such as his playing one insurance group against another, or it may come about by the competitive forces within the insurance fraternity. In either case, the results are usually the same, the driving down of the level of



NFPA No. 13 calls for "one or more fire department connections in all cases" except *where the authority having jurisdiction permits their omission.* Details of the size, arrangement, and hose connections are given in Section 380 of the standard.

the fire protection by reducing the water supply requirements to the barest minimum and perhaps even lower. When the building burns down, everyone is a loser. The owner may never be able to resume operations. He may have been underinsured. His employees may lose their jobs, or, far more serious, some may lose their lives. The community loses in taxes and many other things. The insurance company has a large loss to pay. The sprinkler industry has another unsatisfactory performance added to the score, even though the sprinkler system was placed in the position of having as much chance to perform as a fighter with his hands tied behind his back.

The conditions just mentioned also pertain to the second possibility — inadequacies occurring after the system was installed. The record shows that public water supplies were involved about seven times more than private supplies. Either a change occurred in the public water supply characteristics, or in the hazard being protected.

Periodic flow tests should detect any gradual changes in the public water supply characteristics, but, of course, an abrupt change due to an unusually heavy draft of water at some other point along the main or a temporary impairment at the pumping station could go unnoticed. Should this be existent, or occur at the time of fire outbreak, an adequate supply may be reduced to a very inferior one.

Periodic inspections of the hazard should show whether any structural, occupancy, or housekeeping changes have taken place which give distinct promise of causing more sprinklers to open than the water supply, as originally provided, is capable of handling.

Hazard changes seem to predominate in the large loss fire reports and quite frequently, a combination of structural, occupancy, and housekeeping deficiencies is involved.

We also find too many cases where the fire department connection for the sprinkler system was nonexistent. Un-

less the sprinkler piping has been impaired by ceiling collapse, explosion or the like, what better way is there to reach the fire directly than through the sprinkler piping? A fire department connection to the sprinkler system is for such a purpose, and *every* system should be so equipped.

By and large, the problem appears to center not on the lack of knowledge or the significance of water supply deficiencies or property hazards, but rather on failure to use that knowledge and prompt, constructive action to correct the complicating conditions. Competitive forces again come into play. For an insurance company, for instance, to insist that the owner take prompt action raises the possibility of that company losing the insurance to a competitor who would take over the "risk" as is. The owner himself, in thinking he is a smart trader, may start the ball rolling. In reality, he is defeating his own purpose should he have any desire to perpetuate his business. Long gambles with life and property because fire protection engineering principles have been ignored or compromised, seldom pay off. A sprinkler system, as the record bears out, will do its job if given half a chance. However, we cannot expect that an original installation will take care of every conceivable use the building may be put to or will always be adequate if structural changes are made.

Unlimited Water Supplies

It might be proposed that the water supplies for sprinkler systems be unlimited in volume and of such an assured pressure that every conceivable condition of the future would be satisfied. If such a water supply exists, so much the better, but if it has to be developed, this is another story. Unduly heavy requirements would penalize the owner by having to pay a cost greater than would be warranted. The water supply part of a sprinkler system can be substantial in cost. Private water supplies could involve such items as gravity tanks, reservoirs, fire pumps and maybe, long feed mains. Public supplies may also involve these items along with some added costs depending on the city in which the building is located. Realistic requirements with a fair margin of safety should suffice with augmentation as necessary to suit changes in the hazard as they occur.

Sprinkler System Water Charges

Public water supply costs are affected depending on the city in which the building is located. Picture Main Street, U.S.A., equipped with a large water main capable of furnishing excellent water supply for automatic sprinkler protection and with fire hydrants amply spaced for public fire protection. Owner Jones decides to provide his building with automatic sprinkler protection. His next-door neighbor Smith is not so interested. Depending on where Main Street, U.S.A., is located, the water supply for Owner Jones's sprinkler system may entail a very heavy charge to make connection to the public main. A full flow fire line meter may have to be located in an outside concrete pit. A yearly standby charge may be assessed, based on the number of sprinklers or the size of the connection to the public main. These items can add up to substantial amounts.

Is this fair? Owner Jones has substantially enhanced the fire protection of his building through the installation of the sprinkler system. He also has greatly reduced the hazard of exposure from his building for his next-door neighbor Smith. He pays, as does Smith, in his tax rates for the public fire protection provided by the community. Yet, because Jones goes far beyond Smith in providing the best known means of fire protection for his

building, he is penalized. If Jones is required to pay for the water his sprinkler system might use in extinguishing a fire, then the water that the fire department might use to extinguish a fire in Smith's building should be metered and charged to Smith.

It has been stated that the owner of a sprinkler system, because he is usually the beneficiary of a large insurance rate reduction, can well afford to pay a standby charge. Such a position represents nothing else but double taxation.

It is fair that Owner Jones should pay for the cost of the connection to the public main. He should also pay for any repairs or maintenance for this connection and the piping into the building as they occur. He should not have to pay for anything else. His automatic sprinkler system would use far less water in event of a fire than would otherwise be the case. Only the sprinklers where the fire existed would be operating, with the water coming from a half-inch nozzle as against the many thousands of gallons of water that would be poured on the fire through fire department hose streams. By reason of its water conservation ability, it is a most valuable auxiliary to any water supply system and its use should be encouraged and not impeded by the imposition of water service charges.

Pressure Tank Systems

A discussion of water and the automatic sprinkler system leads us to the treatment for properties where public water supply is not sufficient in volume and pressure. Many such properties exist and there is a solution for a substantial number of them through the use of pressure tanks. Properties where pressure tank or limited water supplies could be considered would generally be light or ordinary hazard occupancies, where a small number of sprinklers could be expected to operate and extinguish the kind of fire that would be expected there, or hold it under control until arrival of the fire department. Properties such as nursing homes, sanitariums, old people's homes, schools, country clubs and the like which are often found in areas with poor public water supplies or no supply at all, and where safety to life is of paramount importance are definite potentials for a pressure tank system.

A pressure tank system not only serves as an alarm system to give both local and remote alarm if desired, but has the advantage of backing up the alarm with immediate fire fighting action. Where sprinklers are on the job, the fire is being fought while fire fighters are on the way. On arrival, if the fire is not already out, the fire department can make a quick hookup to the siamese connection to supplement the stored supply and can be sure of getting water on the fire through the sprinklers that

A 9,000-gallon pressure tank and the valve house for the sprinklers in the Baton Rouge (La.) Country Club.

These sprinklers at the Elgin (Illinois) Country Club are supplied by a 3,000 gallon tank in the basement which is under a pressure of 115 pounds per square inch. The top line of sprinklers on the third floor is 35 feet above the tank.

have opened rather than wasting water and time in trying to get to the heart of the fire with hose nozzles.

We have available a record of one type of small limited water supply system using a pressure tank as a source of water supply. The record covers 159 fires and many of these systems are still in service after more than 40 years. Please bear in mind as we discuss this record that this system has an extremely small water supply.

In only six of these fires was the system performance classified as unsatisfactory. This means a satisfactory performance record of 96.2 per cent, the same as the NFPA over-all sprinkler efficiency record. With these systems, 86.2 per cent of the fires were controlled by three or less sprinklers. This compares very favorably with the over-all NFPA sprinkler performance of 63.3 per cent for three or less sprinklers.

Metropolitan New York City is largely a pressure tank town. Although the pressure tank capacity is larger than for the limited water supply system just mentioned, the record in New York City further illustrates the value of such systems. The water supply in most common use consists of a pressure tank with total capacity of 7,500 gallons maintained at 75 pounds

pressure and augmented by a 10,000-gallon gravity tank acting as a secondary supply. Six hundred to eight hundred fires occur yearly in which only one or two sprinklers operate. Many of these systems have central station supervision, a most desirable feature for every sprinkler system when available. These fires are either extinguished by the sprinklers or held in check for extinguishment by the fire department. Another point of interest is that because of the high water pressure, New York City has been enjoying the advantages of the new spray sprinkler for many years before it came into use in 1953, since the old style sprinkler, when subjected to high pressure, produces distribution characteristics very similar to that of the spray sprinkler.

Pressure tank supplies for sprinkler systems have not received the recognition which seems to be warranted by the performance record. However, there is some evidence now towards a greater acceptance and it is earnestly hoped that this trend will continue at an accelerated rate. Such systems can do much in affording life and property safety, particularly in our rural communities.

Conclusion

What can be done to improve the over-all picture of water supplies for sprinkler systems? First and foremost, a much greater appreciation of the importance of fire protection is needed by top management. There will then be many fewer potentially dangerous flights into the realm of pure chance in attempting to buy insurance for the cheapest price and with fire protection pared to the bone. As one of the leading fire insurance organizations has stated recently, "A serious fire causes loss far beyond anything recoverable from insurance."

Regular inspections of the property should be made to note any occupancy or structural change that would put greater demands on the water supply to sprinklers. By making alterations in the sprinkler system indicated by such inspections an adequate water supply can be assured when fire occurs. In this connection, it should be mentioned that an inspection service is available from many members of the sprinkler industry.

The Committee on Automatic Sprinklers of the NFPA has the responsibility of developing and revising the standards for the installation of sprinkler systems, subject, of course, to the approval of the NFPA as a whole at its Annual Meetings. The wisdom and foresight of this Committee over the many years of its existence is clearly evidenced by the excellent performance record of automatic sprinkler protection.

This record, as compiled by the NFPA, has served in an inestimable way in the development of the standards. The record of large loss fires in which automatic sprinklers are involved also offers much information and it would appear very desirable for the Committee on Automatic Sprinklers to review the facts of each such fire on a continuing basis. While only the Almighty is perfect, there is nothing to prevent us from reaching for this plateau — in fact, it is human nature to do so. We are not too far removed with an efficiency record of 96.2 per cent and the close scrutiny of the large loss fires may point the way to a strengthening of the standards which would make automatic sprinkler protection even more efficient.

NFPA Services to Industry

By Malcolm S. Blake, Assistant Manager
Insurance Department, Bethlehem Steel Company

How does industry use NFPA standards and fire records? That question leads to two others. What does industry do with NFPA standards and fire records? What does industry do as a result of NFPA standards and fire records?

These standards and fire records are fire protection's guideposts to progress. Fire records serve to bring out what was wrong and, with the standards, they point directions by which corrective measures should be applied to stop similar destruction. Fire records alone give only part of what is necessary to prevent or control related experiences. After finding what was wrong, to capitalize on the sad lessons of destruction profitably, it is necessary to follow through, obtain and apply the knowledge of what is right.

In industry this means giving full attention to a number of phases of the problem. It usually requires not only building effective physical fire protection and control features into industrial buildings or other operating facilities, but also developing proper operations and maintenance procedures for personnel wherever avoidance or containment of fire hazards depends upon the performance of people. That element, the human element, enters into the great majority of industrial fire hazard control situations. Further, to accomplish the desired human performance in fire safety requires an effective program of education and persistent training throughout any industrial organization.

If we recognize all of these elements clearly, it becomes plain that the tools required for minimizing industrial fire losses are several and are interdependent, each being equally important. They are: first, the records of fires from which to learn; second, the standards for physical fire control measures developed from that knowledge; and third, the standards and educational media for training and directing the actions of people, to assure that the physical safeguards will perform their intended functions.

There is a tremendous wealth of helpful information published on all phases of this subject. However, I know of only one organization that provides comprehensive information on all aspects of the fire problem for anyone, anywhere. That is the NFPA.

Just how does industry actually utilize the NFPA's many publications? I can speak authoritatively of how Bethlehem Steel Company does so, and from my contacts with fire protection people of other industries, I know that my own Company is far from unique in its practices.

Multi-Membership Plan

First off, my Company makes sure that all of our personnel who should have regular use for NFPA material receive the Association's publications. We do this primarily by maintaining NFPA memberships for those people (now numbering close to fifty). They include all of our fire protection head supervisors and fire chiefs in our numerous plants, as well as all of our fire protection people on our Home Office staff.

Based on an address by the author at the 1958 NFPA Fall Conference held in Pittsburgh, Pa.

Various other persons provided with memberships include certain of our engineering, safety, operating and maintenance personnel at both plant and central management levels. In addition to their regular memberships, to make sure nothing is omitted, we maintain for most of them, too, subscriptions to the NFPA "Book and Pamphlet Service."* That Service brings to members automatically practically all of the additional books and other special publications that would otherwise require individual purchasing attention. Some of the material thus issued, though a surprisingly small amount of it, is admittedly of little direct value to some of our people, but we find it the most practical way of assuring that their possession of NFPA information is always up to date and complete. That is how and where the NFPA publications are directed to our personnel.

How to Use NFPA Standards

To what extent are they used, and in what manner are they applied? NFPA Standards and Recommended Good Practices have proven to be the most valuable and constantly useful tools for guiding development of industrial fire safety. They are basic in the whole approach to resolving a large share of industrial fire safety problems.

Why are NFPA standards used? One of the more important reasons is because they are in large part developed by industry itself, as well as by the several other interests whose knowledge and contributions are essential to their sound development. Such a joint effort has produced ultimate tools that industry finds are not only generally reasonable but essentially practical. They are workable. Another reason for using NFPA Standards is that no one company, or industry for that matter, has in itself the resources or experience, the talent or the know-how that is necessary to come up with a widely different set of comprehensive standards that would be equally successful for all of its fire safety problems.

Most people who apply national standards, realize that such standards cannot and should not be applied to the letter for every situation to which they may pertain. In many ways, they deal with average or common situations and, to be widely used, must of necessity embody reasonable minimum requirements, as do NFPA Standards. Many special fire hazard situations demand more stringent protection requirements and may not be covered adequately or appropriately in standards. On the other hand, some low hazard situations may well require less protection than the average minimums covered by standard rules. Use NFPA Standards as a sound foundation and guidepost upon which to architect your particular fire safety requirements, rather than trying to build your own rules from the ground up. Otherwise, you will determine ultimately that you have been off on the wrong foot and will sooner or later meet yourself coming back.

How are NFPA Standards utilized? In Bethlehem Steel, not only our staff of fire protection engineers employ them regularly in evaluations of our fire and explosion hazards and resolving our protection problems, but our plant fire department chiefs also follow closely many of the standards pertinent to their work. Certain special plant protection rules of our own making are related to these standards. Further, various specific NFPA Standards dealing with pertinent special problems are given to plant engineering and operating personnel in connection with the develop-

*Full information on this NFPA Service available on request to the Association.

ment of answers to recommendations for hazard protection. For instance, when a new plant facility is to be constructed, the Fire Protection Department reviews preliminary plans and specifications with the Engineering Division for determination of hazards and protection needs. The facility may be a new rolling mill, an oil-and-paint storage house, a liquefied petroleum gas tank installation or a new research laboratory, as a few examples. Recommendations for protection are then developed.

It is common Department practice to forward with our recommendations a copy of related NFPA and other standards with a request that in whole or in part they be studied by the Design Engineer with a view to following them as closely as possible. After this has been done, the entire matter is discussed with the Engineering Division and one or more representatives from the Operations Division to agree on all of the standard requirements, or acceptable alternatives, that can or cannot be practically and justifiably incorporated. When such a meeting of minds has been achieved, and if substantial costs are involved, the protection program is then referred to general engineering management for final check and O.K., and thence to top management for financial approval. With this sound approach, the granting of large expenditures is more readily obtained.

Another way in which NFPA Standards receive attention is at our Company meetings of our fire protection personnel leaders. In addition to certain local conferences, top fire protection people from each of the various plants get together periodically with our central fire protection engineering and management personnel to review our fire prevention and protection practices for improvements. It is common procedure at these general meetings to devote time to examining our practices in the light of the specifications of one or another of NFPA Standards. This is an especially fruitful way of keeping in step when new or revised standards have been issued on subjects of special importance to fire protection problems in our industry.

Use of Fire Records

Although everybody is impressed by large fires and other catastrophes, it is not always recognized that an indispensable adjunct to keeping abreast of fire hazards in vulnerable locations of any industrial plant is a thorough and complete fire reporting system. I mean by this a system including all of the small fires which, because of their classification, their locations and frequency, oftentimes reflect important potential trouble spots more effectively than some of the larger or more spectacular fires.

If subjected to a close and constant study, such complete reporting is of tremendous value. My company has had such a system for a great many years and we find it invaluable. Our particular system includes both weekly and monthly reports of all fires from every plant to our Insurance Department and to the plant operating managements. These reports are summarized and then analyzed for important trouble indicators. In addition, immediate special fire reports on a complete data form are required for any fires involving more than $500 of loss. That form is also used by the plant fire chiefs for reporting any fires of special interest such as those involving a particularly valuable lesson regardless of the actual loss.

Copies of fire reports are supplied to the operating management people concerned, including those at plant level who receive reports of every fire that occurs irrespective of loss consequence.

This practice has a most beneficial effect in promoting fire consciousness and a greater interest in the routine fire prevention and protection measures followed throughout the Company. Our Insurance Department investigates, develops and distributes to all concerned throughout the Company specially prepared reports of any particularly large or important fires within our properties. These are usually illustrated with photos and diagrams to stress their lessons.

The circulation of reports of the facts of industrial fires of a magnitude or unusualness to command national or widespread public interest offers, of course, an obvious means of stimulating interest in other segments of industry to take a long and new look at their own fire safety situation. Perhaps the most classic example of this on a national scale was the result of the NFPA report of the General Motors Fire* a few years back, still the largest single industrial fire loss that has yet occurred and which destroyed a physical plant that was thought by many persons to be essentially noncombustible.

The self-examinations in other plants following receipt of the facts of that occurrence were beyond counting and the consequent improvements for eliminating or reducing similar weaknesses were tremendous. I know this, not only from the reaction and consequent steps taken within my own Company but also from reports of similar results in many others. Probably it would have been small comfort to General Motors at the time of such a distressing experience, but the lessons from its loss have been applied to the gain not only to it but to many other industrial firms. It certainly brought forth a wholly new alignment of values attached to a number of fire protection features, such as, to quote just two examples, the importance of adequate fire vents in large-area, single-story buildings and the development of less combustible built-up roof coverings.

Another excellent way of utilizing NFPA fire reports effectively is to place before management one or more reports that particularly illustrate the objectives of specific fire protection proposals that you may have developed and submitted for management consideration and acceptance. It is my experience that such reports, especially those containing good supporting photographs, can help a great deal in obtaining a clearer understanding and greater appreciation of your objectives. The NFPA Occupancy Fire Records,† for example, can often be employed advantageously for this purpose.

*See October 1953 QUARTERLY or QUARTERLY Reprint Q47-2 (25 cents), available from the NFPA Publications Department.

†Available from the NFPA Publications Department.

Human Safety vs. Selfish Planning

By John C. Thornton

Chairman, American Institute of Architects Committee on Human Safety

For the past five years the American Institute of Architects Committee on Human Safety has been making an intense study of what the architect can do to make buildings safer for human occupancy in case of fire.

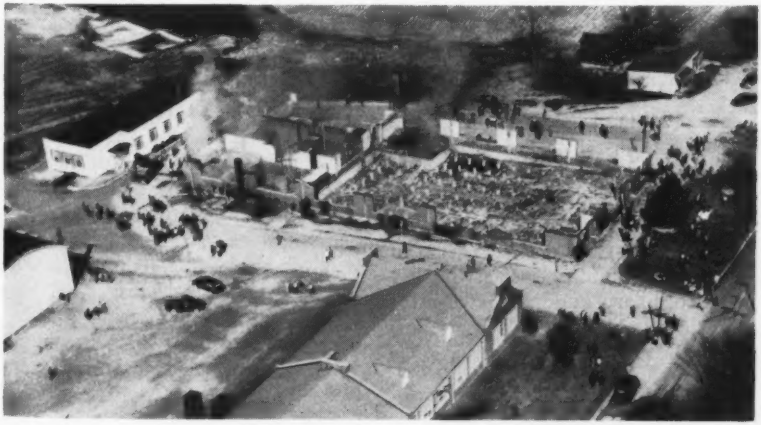
As we studied various occupancies, we were shocked at the lack of thought that was being given to life safety. A great deal was being done toward saving property, but the saving of human life had not received the attention it should have had. Our studies have been on life safety.

Based on a talk by the author presented at the 44th Annual Conference of the Building Officials Conference of America, held May 18–21, 1959, at St. Paul, Minn. and published in the BOCA News for August 1959. Reprinted herein by special permission of the author and BOCA.

Such work as ours takes time. It took us three years before we felt we were making headway in our profession, but now we have definite proof that many of our members are becoming conscious of their responsibility and that fire safety begins on the drawing board.

While the architect by thoughtful design can do many things to make his building safer, he cannot do it all. Often the client is not safety minded and is willing to take chances with other people's lives. He will not allow more to be done than the code requires.

Also, client requirements for certain occupancies are directly opposed to those for life safety. This is what we call *selfish planning* and what we are going to discuss in this article.



United Press Photo

This school near Mt. Airy, N. C., burned on Feb. 22, 1957, and cost the life of one 9-year-old crippled boy and his heroic teacher who tried to save him. Classrooms opened into a centrally located auditorium, and fire, originating in the auditorium, forced the children to jump out of classroom windows some of which were 8 to 10 feet from ground level.

A building is more than a beautiful structure of fine material. It must also fulfill the needs for which it is built. It houses human beings and therefore is a shelter, which means a place of safety. A study of fire records leads us to believe that this phase has been neglected. Safety means more than making a structure strong enough to endure. It must also be designed to protect the occupants from fire. This does not necessarily mean that it must be of fire resistant materials. It is more important that the occupants escape, for if they cannot escape, the materials of construction are unimportant for there is always fuel present in the contents.

The American people are not safety minded. They are willing to take chances. We have an apathy toward fire. Our heritage of wood construction may be to blame. We think we will always have fires and that there is not much we can do about it. We can do something about it if we will but change our attitude.

We think we are a civilized people but we offer up more human sacrifices than the heathens ever did. This may be difficult to prove as their records are a little sketchy.

The word "fireproof," or rather the phrase "fire resistant," has created a false sense of security, that such construction makes a building fire-safe for the occupants. This is not true; you can be killed by the gases of combustion in a fire resistant building just as quickly as in an ordinary building. We must not let down the bars on other safety measures just because the structure is fire resistant.

Windows

While our modern windows may not be *selfish design*, they are certainly thoughtless design. Windows have another purpose than for light and air, they are often the only means of escape or rescue. Our attention was first called to this by the small high windows so popular in bedrooms. They can and have made fire traps of such rooms because of the size of the opening and the sill height being in the smoke zone.

We are using such windows with ventilators too small for escape or rescue in many occupancies. The worst use in our opinion is in our modern schools. We have had many cases, even in modern schools, where the windows were the only means of escape. In a new school near Mt. Airy, N. C., corridors were omitted to save money and the classrooms opened directly into the auditorium. A roof fire cut off this escape. All but two were able to escape by means of the double hung windows.

In the recent Chicago school fire we asked the NFPA engineer who covered that fire what would have happened there if that building had had modern small louvered sash. His reply was that the death toll would have been triple what it was.

On a half day trip I counted 12 modern schools with window openings too small for escape. The fixed window is somewhat the same. It can be broken but in panic the occupant may be severely injured. We believe that every room without an outside door where one might be trapped should have one window that can be opened and used for escape. If smoke is entering the room from the ventilating system, or other source, an open window may provide the only fresh air so necessary for life. This was clearly shown in the Chicago school fire.

The windowless building is being used to such an extent that it is time we realized what we are doing. Such

Many modern stores present difficult problems for escape and rescue. The window area here is less than 5 per cent of the exterior wall surface.

buildings offer little chance for escape or rescue, or for smoke removal, and give firemen practically no chance to reach the flames. There have been cases where all they could do was to let the structure burn. Such buildings are often the result of *selfish planning*.

Doors

Doors have another purpose than for privacy and protection from the weather. They can also save lives, depending upon location, swing, construction, etc., and if they are closed. We now have a fad of using the "open plan," which is also "open" to the spread of fire and smoke. A closed door can save your life.

Most deaths in fire are caused by the gases of combustion, and death comes a comparatively long time before the flames reach the victim. A closed door can keep out these deadly gases for a time and give a chance for life.

Where possible, there should be a door separating the bedroom portion of a house from other living quarters. It might save those who persist in leaving their bedroom doors open at night. The split-level house with open stairs from basement to bedroom level furnishes a path for smoke and flames. We must remember that it does not take a large quantity of smoke to furnish a ticket to eternity; a burning television set or one overstuffed chair can and has done it.

A modern windowless department store. Fire resistive construction protected throughout by a supervised sprinkler system. Open stairway and escalators extending to fourth floor.

The low partition so popular at present offers no resistance to the spread of fire as the hot gases move along the ceiling with great rapidity.

Smoke and fire doors are of no value unless they are closed. We have seen such doors held open with wedges and even floor bolts in some of the largest hotels and office buildings in several cities. This should be made a legal as well as a moral crime.

Stairs and Exits

Stairs and exits are probably the most important element of design affecting fire safety, but we have little reason to be proud of what we have done in the past or are doing with them today. The classic folly of design was the extension of the open stair of the low building to the multistory, as structures rose in height, with no thought of the life hazard created. True, we stopped in many higher structures when the death rate showed us the error, but it is still perfectly legal to die in an older building and there are plenty of them.

In 1858 thirty people were killed in a hotel fire because of an open stairway. We still have them 100 years later. In 1883 seventy-one died because of inadequate exits. We still have them. We cannot blame past generations too much, for we are doing things just as foolish today.

Our codes do not require closed stairs in two-story buildings but open stairs can and have caused many deaths. Smoke rising up the stair can kill just as quickly and you will be just as dead as if it were a higher multistory building. The records are full of such cases.

Fire in the lobby of a small hotel in a western city killed several men in their rooms on the second floor. It was not a large fire but there was considerable smoke. A closed stair would have saved them.

We put great stress on exits and expect them to be sufficient in case of fire. Many deaths occur in buildings with plenty of exits. An exit that cannot be reached gives a false sense of security. We like the term "avenues of escape," which includes the exits and a safe means of reaching them. We, as archi-

tects, have been taught that the entrance should be inviting and easily found. This should be reversed. It is more important that the avenues of escape be prominent, especially where there is danger of panic. We often enclose stairs as required by code but terminate them in dangerous locations. The lack of safe avenues of escape is closely allied to *selfish planning* in several of the occupancies we will discuss.

Supermarkets

The first problem our committee considered five years ago was what we felt to be the greatest unrecognized hazard we have today. We feel it is similar to the open stairways of a few years ago which took great loss of life to bring about changes.

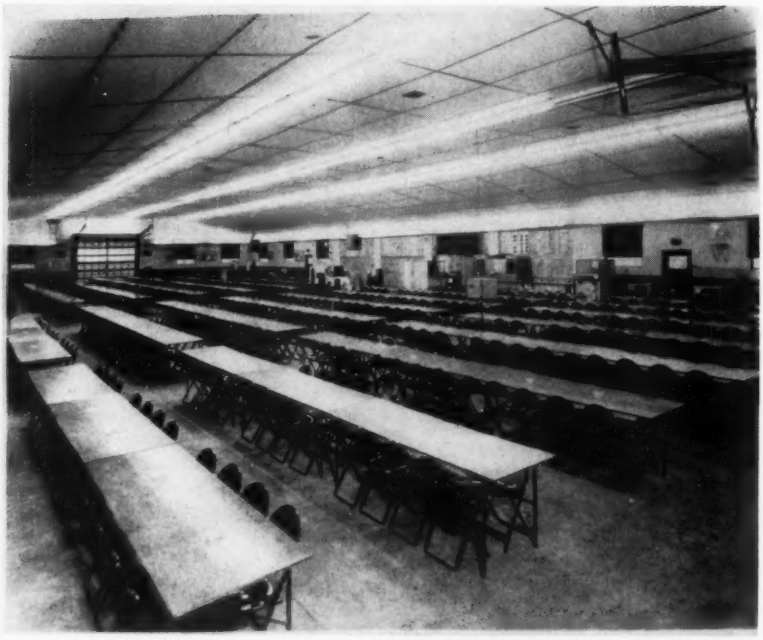
We are referring to the supermarket. In the past 20 years thousands of them have been built throughout the country and codes have not kept up with the situation. Also many are built outside of cities where requirements are not strict and fire protection is inadequate.

While the fire record of this occupancy is very high and the cases of total loss reach a very high percentage, we have been fortunate that there has not been large loss of life. This is due to the fact that many of the fires have occurred at night. Daytime fires have occurred during the less busy hours, but there are many records of narrow escapes. We are due for one in a crowded market and when it comes we will sacrifice many lives not only from the fire but from the attendant panic. The public will then demand that something be done, as it is doing in the school situation today. Why wait for a catastrophe? We have a perfect setup for high loss of life in many of the markets we have visited.

Let us first consider the exits and what is more important, the avenues of escape. The codes call for exits, of course, and specify widths, but the

Los Angeles Times

Two employees lost their lives delaying their evacuation of this supermarket fire in Los Angeles on April 28, 1951. The fire was discovered at 1:45 P. M. but the alarm was delayed while employees tried first to put out the fire with a standpipe hose stream.



Eleven people lost their lives in this building in Brooklyn, Maryland, where a church Oyster Roast was held. Panic was a principal factor as fire, originating in a concealed attic space, spread rapidly over the combustible ceiling and the lights failed.

building plans do not give the picture, for most of the exits are not safe avenues of escape in any sense of the word.

The areas are large, the aisles narrow, and the door by which you enter opens in and has no hardware on the inside, yet it is usually counted. The one exit door is often narrow and often electrically operated. If the power is off, as might easily occur in a fire, it will be difficult to open. The check-out system means narrow aisles clogged with carts and people. Windows offer no escape as they are lacking or high. Some have a few large plate glass windows. Breaking them for escape is about as dangerous as the fire itself. Panic is almost sure to occur. Then the death rate will soar. There are rear exits but to reach them you must go through the service section where housekeeping is often poor, the path is unfamiliar and clogged with boxes, cartons and barrels, and when you reach a door, if you do, you may find it padlocked. I have seen such conditions.

Seventy-eight per cent of supermarket fires originate in the service section.* These fires spread to the rest of the building through combustible partitions and into the attic space where they spread rapidly and sometimes the first indication of a fire is when the ceiling starts to fall.

In a fire in 1949, where the fire spread through the ceiling space and was not observed until the ceiling fell, thirty-nine people were burned.

*See NFPA Occupancy Fire Record on Supermarkets (FR 54–2, 50 cents each).

In 1951 another fire caused two deaths. Fire in the roof space traveled so fast the roof collapsed soon after the arrival of the fire department.

It is not a pretty picture to think of what would happen if the market were crowded and a flash fire occurred, and most supermarket fires are flash fires and total losses.

The exit difficulties in this occupancy are the result of *selfish planning*. Management is so concerned with possible theft, probably with good reason, that this takes precedence over the life safety of their customers.

You say that some stores have two customer exits. Yes, I have seen them. In one case a combustible partition was built along the length of the store so that you had to go to the same location to reach either exit. In another case, a ceiling fuel burning heater was carefully placed over each exit.

It is impossible, and not even desirable, that codes try to cover all safety measures, but in this case there must be tightening of requirements. We have written several articles on this hazard which have been published; in fact one article published by the National Safety Council went to the trade but nothing has been done.

Let us now consider what should be done.

1. Stop counting as exits door openings that are not safe exits.

2. We must have adequate exits and safe avenues to them. This means exits from the sales space. Such doors could be equipped with anti-panic locks and alarms which would preclude their being used except in emergency.

3. The partitions between the service section should be of fire retardant construction and pass through the roof.

4. The ceiling should be of fire resistant or low flame spread construction. If there is any combustible material in the ceiling space, cutoffs to stop rapid spread of fire should be provided.

5. Automatic vents, especially in the service section, should be considered to stop rapid spread of flames.

6. The incinerator should be in a fire resistant room or better in a separate building. This also applies to the heating plant.

7. A separate ventilating or air-conditioning system should be installed in the service section so that smoke and flames would not be carried into the sales section.

8. In one flash fire which was a total loss and resulted in narrow escape for the few people in the store, a boy had piled antifreeze near the heating plant. Our recommendation is that there be a cool, vented, fire resistant room for storage of flammable liquids which would cut down the amount kept in other sections.

9. As many fires start from the refrigerating equipment, screen guards should be required so that merchandise piled near it cannot cut off ventilating air.

10. Sprinklers should be required in the service section and a fire detection system should be considered, especially in the ceiling space.

11. As the electric service is usually in the service section, the chance of power being cut is such that it should be brought in at some other point and emergency lighting provided as darkness can add to chances of panic and the electrically operated doors become difficult to open.

12. Means should be provided for firemen to reach the flames and vent the building. Where there are no windows, panels should be provided.

13. Parking should be arranged so as not to interfere with the firemen reaching the building easily.

We all know the results of the Church Oyster Roast Fire which occurred near Baltimore in January 1956 (see photo, page 140).* Nearly every supermarket has much worse conditions. The ceilings are often combustible, there is much more fuel present and the exit facilities are not comparable to those in this holocaust.

When the plans are submitted for approval they may have the total widths required by present codes, but they do not show the conditions when the public is admitted. In many cases the total opening is counted without considering that most of them are not safe exits and that when the aisles are laid out, the distance to an exit may be double what it appears on the plans.

We realize that codes cannot cover all safety measures, that the designer must think beyond the codes if he is to design a building for fire safety, but in occupancies such as this and others I will mention where the owners require conditions that unduly risk the lives of their customers, authorities must step in and require that the public be protected.

The average supermarket, when crowded, is one of our greatest but unrealized hazards in case of fire, not only from the fire itself but from the almost certain panic when the occupants realize the difficulty of escape. It took the Iroquois Theater fire to awaken us to the hazards to life in that occupancy and serious loss of life in hotel fires to teach us that open stairways and elevator shafts can cause many deaths. Must we wait for large numbers of our fellow human beings to give up their lives before we correct conditions which are evident to us now?

*A full report appeared in the April 1956 NFPA QUARTERLY and has been reprinted in NFPA Pamphlet Q49-5, 25 cents per copy.

Department Stores

The department store is another occupancy that because of *selfish planning* risks the lives of the occupants.

Stairs, elevators and moving stairways are located far from exits with the idea that customers will pass many counters and stop to buy. Then some counters are usually loaded with highly combustible merchandise.

Stairs to basements are often open so that in case of a basement fire the first floor would quickly become untenable.

We do not like the open moving stairway. Though protected by sprinklers, the heads would not fuse quickly enough to stop smoke, and smoke can cause panic. The people might not be burned if the building is sprinklered, but panic can cause as many or more deaths than the fire. The 12 inches to 18 inches drop around these openings are of little use as research has shown that draft curtains must be at least 6 feet deep to be of value.

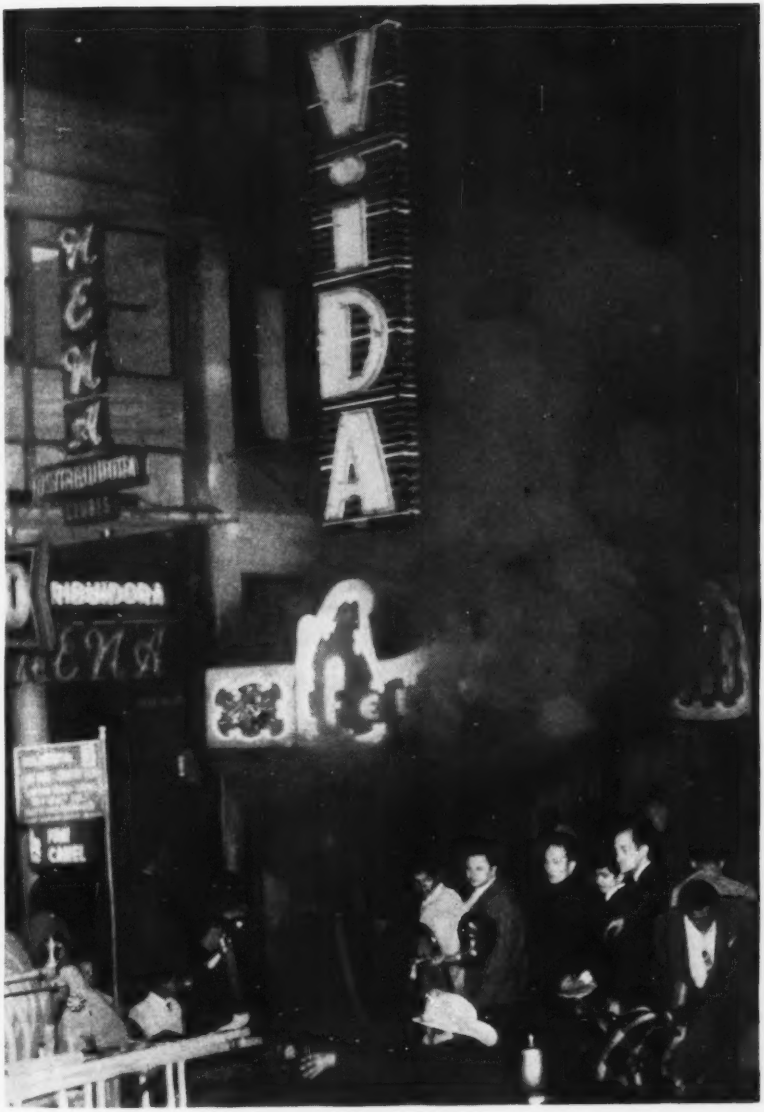
This is an occupancy where there may be plenty of exits but the avenues of escape are poor.

The fire in a department store in Bogotá, Colombia,† took 83 lives. We believe the setup for large loss of life is present in many of our department stores and we are unfortunately due for a tragedy in the United States.

Hotels

Another occupancy which shows *selfish planning* is the hotel. While many of our older hotels have open stairways, our modern ones usually have closed stairs terminating in an open mezzanine or the lobby which can easily be filled with fire and smoke. Shops filled with

†A report on this fire was published in the NFPA Fire News for January 1959.



Flames cut off the escape of 83 shoppers and clerks in this department store in Bogotá, Colombia, on December 16, 1958. The fire originated in a crèche erected in the sales area. A combustible fiberboard ceiling plus inadequate "avenues of escape" were principal reasons for the heavy loss of life in this unsprinklered building. The author warns "we are unfortunately due for a tragedy in the United States" because of "selfish planning" in department stores.

combustible merchandise often surround the lobby.

Such conditions do not provide safe avenues of escape. Exit stairs should always lead directly to the out-of-doors. This is not only for escape but so that firemen can reach the fire quickly. A recent fatal hotel fire in Detroit demonstrated this. A shop fire spread to the lobby cutting off escape for those above who were rescued by firemen through windows. Some escaped by a rear stair. What if the windows had been like those used in modern hotels?

Motels

We thought motels were safe until we began to read the fire reports on them.* Here fire spreads by means of the long attic spaces. A falling ceiling may be the first indication you have of the fire. This calls for divided attic spaces and fire detection systems.

Office Buildings

There have been some office buildings constructed lately that indicate *selfish design.* Putting all the required stairs in a separate tower, or at one end of a long building, does not give two separate avenues of escape. A fire can easily cut off escape, and such a plan can keep the firemen from reaching the flames.

We were recently told of a night fire in such a building where the only access to the flames, which spread by means of the windows, was from the outside. This would have been difficult at the 20th floor. It makes a very usable plan but does not take fire safety into consideration. We called attention to this in a talk last year. Another speaker the next day mentioned what a fine plan this was and that they did not have fires in office buildings. A bad fire has since occurred in the building he discussed.

*See NFPA Occupancy Fire Record on Motels (FR 57–4, 50 cents each).

Churches

Many of our churches are not as safe as we think. Church fires are on the increase and 50 per cent of them are total losses.** Concealed spaces are the primary reason for rapid spread. One of the great dangers in church design is the open stairway from basement into an exit way. A basement fire could make this exit useless because of smoke.

Air Conditioning

It is strange that when we design something new we forget all that we have learned the hard way in former years. This is best illustrated by what is being done with air conditioning. It took us years and many deaths to eliminate the open stairway in certain new buildings, but today we are installing air-conditioning systems that can spread fire and smoke throughout a building faster than the open stairways ever did.† Many such systems are really designed for death. Leaving out safety devices is *selfish design.*

We may be under the impression that in fire-resistant buildings there are always fire dampers in the ducts, but it is a startling fact that they are omitted in some cases. In one tall building where fire dampers were omitted there is not a single device to shut down the fans except in the penthouse. It would take but 12 seconds for smoke to reach every section of the building.

Every system should have electronic devices to shut down the fans at the first indication of smoke in the ducts. Fused fire dampers will not operate soon enough to stop smoke and the presence of smoke throughout a building can cause panic, which can be as bad as the fire itself. The buildings are tight, with

**See "Churches are Burning" ($1.00 per copy) and NFPA Occupancy Fire Record on Churches (FR 56–4, 50 cents each).

†See NFPA Pamphlet Q44–2 (35 cents each).

fixed windows, and the ducts will suck in the gases and heat from the fire location and send them to every room, often adding the fumes from burning insulation. Occupants are sentenced to death just as surely as the criminal is sentenced to the gas chamber.

This is not idle talk. In a recent fire in an air-conditioned building the occupants on the eighth floor panicked and could not reach the stairs. They were rescued by aerial ladders after breaking glass window lights. It might be well to have the same device that shuts down the fans open louvers to the out-of-doors so the ducts can act as natural vents.

If there is smoke throughout a building, firemen would be delayed in locating the fire. I believe that the term "smokalating system" is a truer name than air-conditioning system for many installations. Smoke can cause panic and death although the fire is not dangerous enough to forestall escape. An air-conditioning system can be a means of saving lives or be one of our worst hazards, depending upon its design.

Venting

Recent fires have awakened us to the need of automatic venting of buildings to remove heat and the gases of combustion in order to cut down the spread of fire. We feel that it is one of the most important studies in today's battle against fire. Our approach to venting has been toward the saving of life.

Most of us think of it as something new. It is not new at all; it is just that we have been blind. The Indians used it in their tepees. Our fathers knew about it when they designed their stoves. There was a check in the smoke pipe, but there was always an opening in the check so that there would be a way for the gases to escape so they would not get out into the house to kill them.

We did have venting in many of our buildings in the form of monitors and skylights but as we no longer needed them for light and air, we dispensed with them and put in solid roofs over large areas inviting the hot gases of a fire not only to cause rapid spread of the flames, roof failures and inaccessibility for firemen, but more serious, to kill the occupants. It is just another case of having to wait for large losses to make us think.

A great deal of effort is being applied to the problem, but to date it is aimed at saving property. We must consider automatic venting for the saving of life because so many are being killed by the gases of combustion which cannot escape from our burning buildings. We carefully put in scuppers in some of our buildings to drain off water to save property but provide no means to remove smoke to save human lives. That is *selfish planning*. In buildings the gases rise and expand rapidly and if there is no way for them to escape, they will spread out to carry death to those asleep or who cannot escape.

We believe that automatic venting should be considered at the design stage for every building, especially those where people sleep or gather in large numbers. In some buildings this is a difficult problem but difficult problems should be a challenge to us. We hope that a study will be made of venting for safety to life.*

Materials

Building materials present one of our most serious problems. Manufacturers selfishly put materials on the market without knowing much about them, especially how they act under fire con-

*See NFPA Pamphlet Q50-2 on "Roof Vents for Fire and Smoke" (25 cents each); the 1959 NFPA Advance Reports, pages 99 to 111; and "Operation School Burning" on the Los Angeles School Fire Tests ($4.75).

ditions. Codes are trying to take care of this but the fact remains that thousands of our buildings have walls and ceilings covered with materials that carry fire with lightning rapidity. We heard of one manufacturer who said, "If your code will not permit us to use our material here, there are plenty of places where we can sell it." To overcome that sort of *selfishness* we believe that manufacturers should be compelled to mark their products with their flame spread rating.

Panic

We should mention designing to lessen the chance of panic. We are now making a study of what can be done.

It is a beastly frame of mind which makes animals out of men and is caused by sudden fear that escape is impossible. No class of people is free from it. Education or previous experience, such as being police or fire officers, does not assure that you will not panic. Children under school supervision seldom panic but put them on their own and they will be like everyone else.

Panic is more apt to happen in basements and in the dark, indicating that there should be emergency lighting for avenues of escape. An exit sign is of little use in panic for people do not read signs at such times. We will have to find a surer method of helping people find an exit.

We must make egress easy and natural because if people believe that they can get out they will not panic. One place where this is needed is in churches, especially those which persist in having candlelight services where open flames are carried around the sanctuary. I am not referring to candles at the altar. Churches have a responsibility for the temporal as well as the spiritual welfare of those who attend their services.

Conclusion

You may be able to do something about a few of the things we have mentioned, such as making supermarkets safer than they now are, and we hope you consider such things.

We realize that safety cannot be legislated. In our work at the American Institute of Architects we are making definite progress but architects are handicapped as you are and we will not get very far until the public in general becomes safety minded.

We must get the message of fire safety in the design of buildings to everyone who has anything to do with them: owners, lease holders, architects, engineers, contractors, building officials, and also manufacturers of building materials and equipment. They have all been guilty, some from lack of knowledge or interest or because the silver dollar casts such a deep shadow on the problem that they cannot see it nor do they care.

When *selfish planning* endangers the lives of our people, education will accomplish little; it is then that the government must step in and protect our citizens.

Fire safety in building design need not be costly except in the time required to familiarize ourselves with the problem and that needed for thoughtful design and careful enforcement. In other words, use the upper part of our superstructure called the brain a little more to foresee hazards and not wait for statistics to motivate us.

Models and Fire Research

D. I. Lawson

Director, British Joint Fire Research Organization

A little thought will show that the scientist working in the fire research field is up against some rather formidable problems. First of all, to say that no two fires are exactly alike savors of understatement. The scientist usually meets a challenge of this kind by carrying out a large number of experiments and resorting to statistical methods. Experiments involving fires in full-scale buildings cost money, and by the time all the variables have been explored the cost of the cure may well be more than that of the ill.

Fires in buildings occur sporadically and so the scientist has no hope of taking measurements. Although a number of scientists stay overnight at fire stations, their chance of seeing many fires of importance is still very small. The scientist is mainly dependent on reports from fire departments for his knowledge of fires in practice. These reports form the basis of all our statistical knowledge about fire and are the starting point of many valuable operational surveys. Taken alone, however, they are not suitable for a scientific inquiry into fire problems; there are too many variables, measurements cannot be taken at real fires, and reports of what takes place must come from observers otherwise occupied. Obviously some additional approach must be found.

The ideal solution, of course, is to bring the fires into the laboratory, control the conditions as far as possible, and study the variables one by one. The results of the laboratory work may then be compared with the practical experiences of the fire departments to check that no significant factors have been overlooked in the laboratory. In order to do this it is necessary to devise a valid model technique.

For some purposes mere small replicas are acceptable. A little girl will find a doll's house an adequate representation of the houses that grownups live in. In the same way a boy will delight in a scaled-down replica of a railway engine, and if all the bridges and platforms are scaled down in proportion the engine will appear to move past them at about the same relative rate as a full-scale locomotive. This is because velocity is proportional to distance covered if the time dimension is kept constant. Of course, things do not always turn out so well as this. Sometimes large liners are represented by models on the motion picture screen and the waves look wrong due to a failure to preserve the correct relationship between linear dimensions and gravitational and surface tension forces in the model. The house of the little girl, though visually correct, would not fulfill the requirements of the heating and ventilating engineer as a piece of experimental apparatus,

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The British Joint Fire Research Organization is a unique combination of interest between the government, through the Department of Scientific and Industrial Research, and the insurance companies, through the British Fire Offices' Committee. It operates a Fire Research Station at Boreham Wood near Elstree in Hertfordshire. The accompanying article covers parts of principal interest to NFPA readers of an article which appeared in *The London Times Science Review* for the autumn of 1958, reproduced by permission. The illustrations are British Crown Copyright and used by permission.

nor would the model railway engine satisfy the designer of locomotives as a working model.

A heat problem will usually contain a number of variables such as length, temperature, velocity, density, viscosity and gravitational force, and these may be grouped to form dimensionless quantities in the same way that length divided by the product of velocity and time was a dimensionless quantity in the simple example of the boy's train. In this case the scaling of the length dimension accompanied by an equal scaling of velocity would keep the size of the dimensionless quantity the same. The heat problem is further complicated by the fact that some of the individual variables have to be raised to various powers in forming dimensionless quantities, and in scaling the length, suitable adjustments have to be made to the other variables to compensate for this change. This may mean that the medium in which the experiment is carried out may have to be changed. If one is fortunate enough to know the differential equations describing a problem and the boundary conditions, a model may be designed because the dimensionless groups will be known. It does not follow, however, that it will be a useful model since it may not be practical to effect the compromise necessary following a change of the length of scale. If a process is complicated, as is the case when studying the growth of fire, different mechanisms may predominate at different times, and then it will be necessary in studying the development of a fire to use more than one model, the type depending on the stage of development one is interested in.

A new laboratory has been erected recently at the Fire Research Station at Elstree for the study of model techniques. This is a building 150 feet long, 50 feet wide and about 40 feet high in which fires can be carried out at a number of scales to study the effect of dimensions on the growth of fire. Unfortunately, it is not possible at this stage to forecast the effect of size as is the case in ship and aircraft design because the relative importance of the fundamental processes involved cannot be assessed. The best that can be done is to estimate which factors are likely to be important and to build models so that the relationships between quantities describing the processes are preserved. The validity of the various hypotheses is then tested over a range of sizes of model.

The progress of a fire may be conveniently considered in four stages; first, the combustible material becomes ignited, then the fire spreads from the point of ignition, at a later stage the building becomes involved in fire and the structural elements are subjected to heating; finally, the fire is extinguished. The investigation of each of these stages calls for appropriate modeling techniques.

It is clearly important to understand the circumstances under which materials become ignited in order to reduce the number of outbreaks of fire. Ignition may take place in a few seconds, as is the case when materials are in contact with an incandescent source or when they are subjected to intense radiation at a level similar to that experienced within a few miles of a thermonuclear explosion; on the other hand, ignition may take place only after many months or even years, as happens when some materials are stored in bulk.

The processes involved seem to be different; short-term ignitions appear to be governed by physical principles only, since the theoretical predictions as to when ignition will occur under given circumstances agree fairly well with those obtained in practice, if the as-

sumption is made that the substance being heated is thermally inert, and that ignition takes place once a given temperature is reached. This leads to a dimensional analysis of the heating of solids.

It turns out as one might expect, that the significant quantities are the heat absorbed by the specimen and the heat lost by it per degree rise of temperature before ignition. If these quantities are divided by the heat capacity of the specimen (product of density, specific heat and thickness) the first will have the dimensions of temperature and the second will be dimensionless. Figure 1 shows the results of a number of experiments expressed on a single curve. In these experiments the ignition times vary by a factor of 20, the energy applied to a specimen before ignition by a factor of 7, and the specimen thickness by a factor of 3. The intercept on the axis is the temperature at which ignition takes place. For specimens so thick that the surface not exposed to heat remains cool, the thickness of the specimen is not significant in arriving at an expression for the heat to raise its temperature by one degree. The heat used in raising the temperature of the specimen is controlled by the rate at which it diffuses from the surface and the specimen thickness is thus replaced by a factor involving thermal conductivity, specific heat, density and time.

Of course the results are dependent somewhat on the size of specimen. It is not practicable in the laboratory to apply radiation uniformly over areas in excess of 1,000 square centimeters of sufficient intensity to cause ignition, and intense radiation fields of about 60 watts per square centimeter can only be applied uniformly over areas of about one square centimeter or so. These areas are much smaller than those irradiated when, say, a neighboring building is on fire, and so the effect of size of specimens has to be investigated. Small irradiated areas are subjected to sideways conduction, the effect of which has been investigated by P. H. Thomas at the Fire Research Station. Once the level of the igniting radiation exceeds about 12 watts per square centimeter,

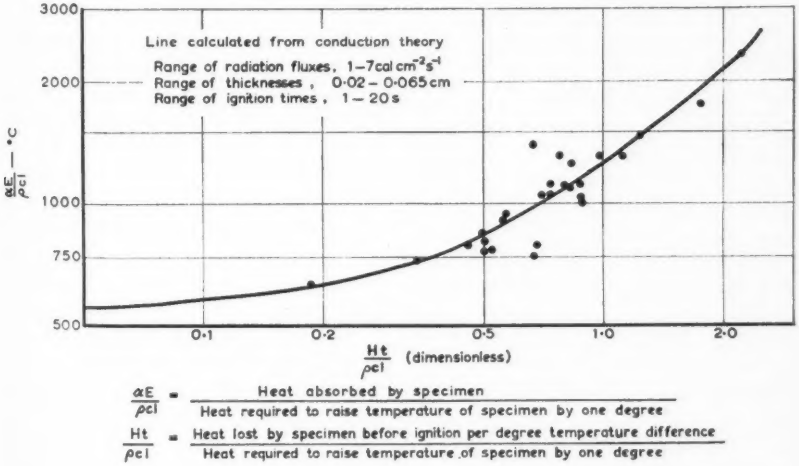
3000
2000
1000
750
500
Line calculated from conduction theory
Range of radiation fluxes, 1–7 cal cm⁻² s⁻¹
Range of thicknesses, 0·02 – 0·065 cm
Range of ignition times, 1 – 20 s
αE/ρcl — °C
0·1
0·2
0·5
1·0
2·0
Ht/ρcl (dimensionless)
αE/ρcl = Heat absorbed by specimen / Heat required to raise temperature of specimen by one degree
Ht/ρcl = Heat lost by specimen before ignition per degree temperature difference / Heat required to raise temperature of specimen by one degree

Figure 1. Correlation of data on the ignition of thin materials.

the time at which ignition occurs is so short that sideways conduction is negligible.

The spontaneous ignition of stored materials is rather different in kind and here the main interest is to find the size of pile that may be safely stored. A chemical reaction takes place in which heat is released, so that if the pile of stored material is large enough for the heat losses to be small, the reaction will proceed to the point at which ignition occurs. Now it is possible to produce these effects on a small scale provided the heat losses are reduced by arranging for the ambient temperature to follow the temperature at the inside of the pile. The heat transfer processes may be represented by an electrical model in which the resistances represent the thermal resistance and the electrical capacities represent the thermal capacity (density and specific heat) but so far it has not been possible to represent the heat generated which varies exponentially according to the Arrhenius Law with temperature. D. A. Frank-Kamenetsky in the U.S.S.R., P. L. Chambré at the University of California, and P. H. Thomas in Britain have, however, managed to solve certain simple configurations analytically.

Growth of Fire

The development of a fire is influenced by several factors among which is the degree of dispersion of the fuel. Straw burns much more rapidly than timber in bulk because for any given mass the area available for the reaction is greater for straw. In the case of dispersed combustible dusts, the surface area is so great that the reaction proceeds with explosive violence. Recent work with rooms of various scales shows that if the degree of ventilation of the fire is high, the rate of burning is proportional to the surface area of the fuel (Figure 2). As the degree of ventilation becomes less, the history of the fire will become less dependent on the dispersion of the fuel, and the rate of delivery of air to the fire will become the controlling factor rather than the availability of fuel.

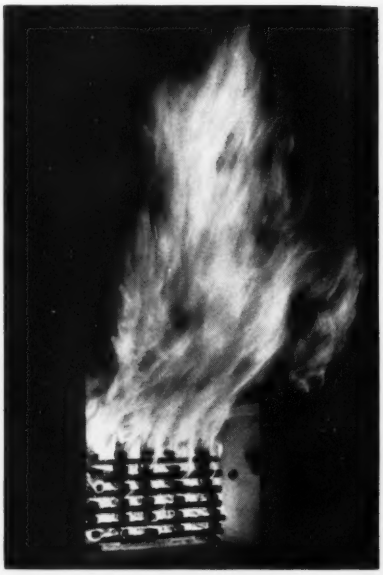

Figure 2. Experiment on the rate of combustion of wood in an enclosure.

Fires require rather more air for combustion than might be imagined at first sight. For example, a fire in the contents of a domestic room will require at least 60 air changes for complete combustion, and it is small wonder therefore that many fires fail to develop if the windows and doors of rooms are closed.

The supply of air to the fire depends on convection, the fire producing a rising column of hot gases and cold air being drawn in at the base. In an enclosed compartment the motive force will be the excess pressure at a point just outside the window sill as compared with a similar point inside the window. This will be roughly the pressure difference between a column of

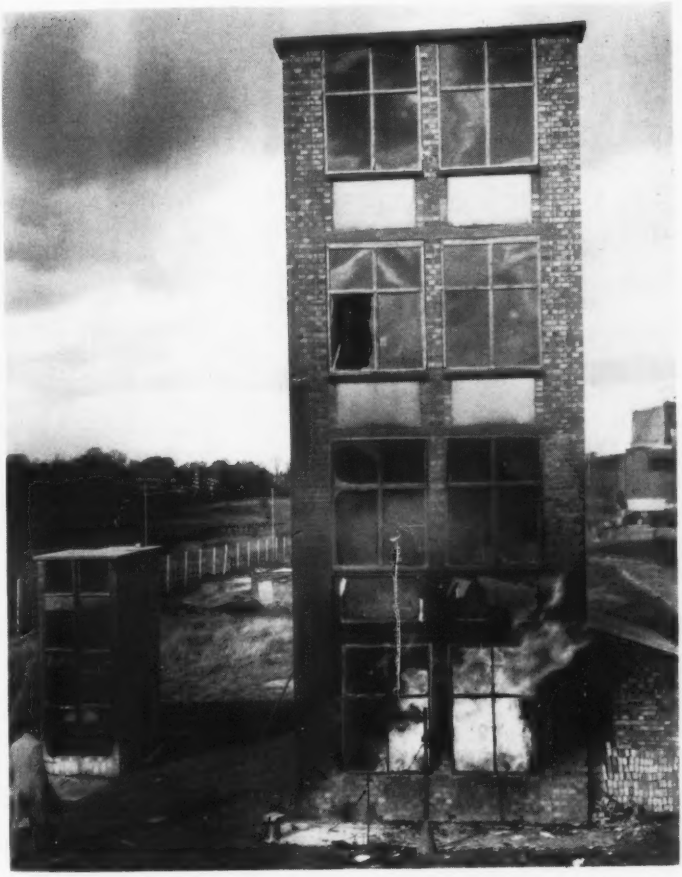

Figure 3. Building for studying growth of fire, with a one-third scale replica (seen at left).

air outside the window at ambient temperature as compared with a column of hot gas inside the window, both having the height of the window. For any given amount of combustible material per unit area, the air supply in a model will be less than that in a full-scale building; a greater proportion of the combustion will take place outside and therefore the relative size of the flames outside the building will be greater. It is important to bear this in mind in model experiments designed to decide whether a fire is likely to spread upwards from story to story over the façade of a building; here the degree of spread is controlled by the size of flames issuing from the burning rooms. Figure 3 shows a building which has been used for considering this kind of investigation and the opportunity has been taken of modeling these experiments on a one-third linear scale to learn something about the scaling factors involved.

A still smaller one-ninth scale building is being used in laboratory studies.

Of course, a fire is likely to spread not only through the building on fire but also to other buildings. The transfer is by radiation and convection. The rules governing convective transfer between buildings on fire are not well understood at present, but certainly they will include a relation between the area of the window openings and the volume of the compartment on fire, the distance of separation of the buildings, the nature and amount of stored combustibles and the wind velocity prevailing at the time of the fire. It is interesting to note that nearly all mass conflagrations in the United States have taken place when wind velocities have been in excess of 30 miles per hour.

The heat transferred by radiation depends on the temperature of the fire, the area of the window openings, their orientation and their distance from the exposed building. Although the mechanism is well understood the calculations are tedious. To facilitate these it is only necessary to construct a model of the burning façade, illuminate the window openings and areas representing issuing flames, and measure the light received by a photocell, as shown in Figure 4. In constructing these model façades use can be made, of course, of photographs taken during the course of actual fires.

Behavior of Structures

Modern fire resistive buildings are constructed so that a fire will not spread beyond the compartment in which it originates, and therefore walls, floors and columns must remain integral during a fire. At the same time the partition walls must not transmit heat at a rate such that any stored combustibles outside the compartments become ignited.

This necessitates subjecting elements of structure, as near full-scale as possible, to fire conditions in furnaces. These tests are both costly and time-consuming, and are a constant challenge to the scientist to find other solutions. The transmission of heat even under the transient conditions of a fire is in theory a relatively straightforward matter, but the application to any particular example usually involves extremely tedious calculation. To overcome this, an analogue machine has been constructed which in effect models the heat problem in electrical terms. Use is made of the fact that the transmission of heat through a slab is paralleled in electricity by the flow of electrical charge through repeated chains of series resistances and shunt capacities. The construction of such a machine has been described by J. H. McGuire and the writer. It may be noticed in passing that the same machine may be used in the study of ignition problems over the range at which it may be assumed that the heat liberated by chemical reactions is not important and that ignition takes place once the solid has reached some given temperature configuration. The predicted fire-resistance of structures obtained by computation in this way is of course only as precise as the data available for the machine, but this is usually known sufficiently accurately to advise on the type of structures which are worth submitting to furnace testing.

The really unknown factor in predicting fire-resistance is the mechanical behavior of structures under fire conditions. Spalling may take place, thus weakening the structure or removing thermally insulated cladding from some important load-bearing member. This difficulty, more than any other, prohibits the prediction of the fire performance of structures. Spalling, which is the flaking away of part of the structure,

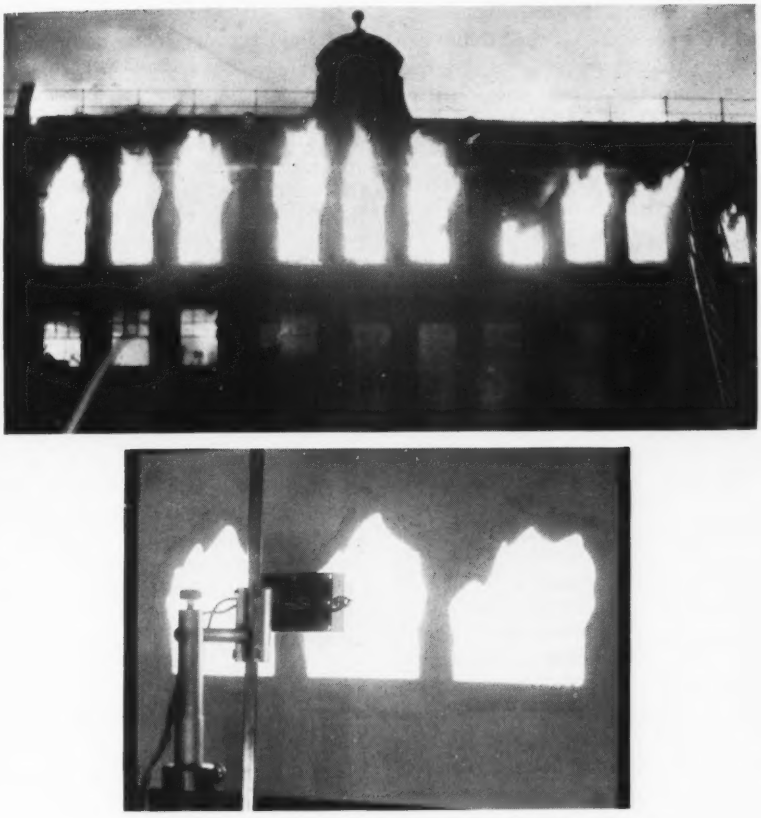

Figure 4. Calculation of radiation from burning buildings with a photo-cell model (lower photo).

sometimes with explosive violence, usually takes place in structures of large cross-section rather than small ones, so that any model testing is precluded until more is known about this.

Prestressed concrete beams of various sizes have been subjected to furnace tests. The predicted times of failure for the larger beams were lower than those obtained in practice due to spalling. On the other hand, if the results of a larger scale test in which spalling is absent are known, it is safe to predict the performance of a smaller structure under fire conditions. The structure is regarded as being made up of a load-bearing element protected by thermally insulated cladding. If the temperature at which the load-bearing element fails is known the prediction of the fire-resistance becomes a problem in heat transmission.

L. A. Ashton, C. T. Webster, and the writer, by examining the performance of a number of timber beams of varying cross-sectional dimensions, have shown that the fire-resistance of load-bearing timber beams in fires may be predicted

on the assumption that the beam slowly chars in a fire and that the strength of the uncharred wood remains constant and falls rapidly to zero once charring takes place. They have extended their analysis to deal with the fire-resistance of floors.

Most experiments on extinction have been carried out at full scale, but in a series of experiments carried out in fires in model buildings by Thomas it appeared that the mechanism of control in confined spaces was the replacement of oxygen by steam and that the quantity of water required for control increased in approximately direct proportion to the volume of the compartment on fire.

One of the problems of fire-fighting is that buildings become smoke-logged if the aeration of the fire is poor; this makes it difficult for the firemen to locate the seat of the fire and indeed fighting such fires entails some risk, for if the windows suddenly break or if a door is opened the atmosphere becomes diluted with air and where it previously was too rich to support combustion it will now burn with almost explosive violence. It is to combat this that the idea has been developed of opening a section of a roof during the early stages of the fire to release smoke and hot gases. This necessitates the study of flow and mixing patterns. Small-scale apparatus is now being used to study the conditions under which a clear passage will be left along which the firemen can approach the fire as the smoke and hot gases are released.

From what has been said it will be appreciated that scale experiments are of the utmost importance in studying the problems of fire protection and in many cases they offer the only hope of studying these problems under laboratory conditions. Where once it was felt that many of the problems were so complicated as to offer little chance of solution, groups in different countries are now actively engaged in the modeling of fire problems. Very much remains to be done but here and there useful results have been achieved; before long it should be possible to examine the structural requirements for buildings in relation to their stored combustible material and the ventilation of the fire.

Friction Spark Ignition of Flammable Vapors

A friction spark may be defined as a mass of burning metal which has been sheared off as a result of impact and friction between two metals or between metal and a hard or abrasive surface. Initially, a particle of sheared metal is heated by the heat generated by the impact and friction.* Depending upon the ease of oxidation and the heat of combustion of the particle, its freshly exposed surface may oxidize at the elevated temperature, and this reaction may increase the temperature of the particle until it is heated to incandescence. Other properties which affect the spark characteristics of metals are brittleness, hardness, heat conductivity, and specific heat.

This article summarizes part of Report Issued by U. S. Naval Weapons Plant, NavOrd Report 5205, on "Sparking Characteristics and Safety Hazards of Metallic Materials," prepared by Harold Bernstein and George C. Young of the Engineering Department. Copies of the original article may be procured from the Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C., by referring to PB #131131, for $1.00. NavOrd Report 5205 reviews literature references to the theory of sparking, methods of spark testing, and ignition hazards associated with the friction and impact spark hazards of hand tools (both ferrous and nonferrous). The authors conclude that no benefit is gained by employing non-sparking hand tools in place of steel to prevent explosions.

*In the October 1957 QUARTERLY (Volume 51, No. 2), a report was issued on "Friction Spark Ignition in Crash Fires" by John A. Campbell of the National Advisory Committee for Aeronautics (now National Aeronautics and Space Administration).

Support for the Oxidation Theory

Numerous tests conducted by petroleum companies support the theory that friction sparks are the result of oxidation. For example, grinding tests have shown that the character of the metal has a great deal to do with the nature and quantity of the sparks produced. Brass, a metal highly resistant to oxidation, produced only a very few dull red sparks when held against a grinding wheel. Certain oxidation-resistant alloy steels produced brighter red sparks while, with the same degree of friction, ordinary carbon steel produced large quantities of white sparks. By pressing relatively mild steel against the wheel to preheat the metal surface, sparks were produced which were sufficiently large and hot to ignite gasoline vapor. The larger particles usually have oxidized edges and the smaller ones may be almost completely oxidized.

Tests conducted in oxygen-deficient atmospheres indicated that the initial impact or friction started the temperature rise, but that the principal heating resulted from oxidation.

Energies generated by the oxidation of copper and iron are shown in the following equations:

(1) $3Fe + 2O_2 \rightarrow Fe_3O_4 + 266{,}000$ calories

(2) $4Cu + O_2 \rightarrow 2Cu_2O + 79{,}800$ calories

Equation (1) states that 168 grams of iron (3 × atomic wt.) when oxidized to 232 grams of iron oxide will generate 266,000 calories, or $\frac{266{,}000}{168} = 1580$ cal-

ories per gram of iron. Equation (2) similarly states that 254 grams of copper when oxidized to 286 grams of copper oxide will generate 79,800 calories, or $\frac{79,800}{254} = 314$ calories per gram of copper. It follows that a particle struck from a copper tool produces only one-fifth the amount of heat produced by an iron particle of the same weight. As their specific heats are about the same, the resulting particle temperatures will be in the ratio of 1 to 5.

Under laboratory test conditions the ignition temperatures of many hydrocarbons are within the range of 450° and 750°F. It has been pointed out that fragments from steel tools, which become incandescent and appear as sparks, must necessarily reach temperatures ranging upward of 2500°F. Such sparks would be able to ignite any combustible hydrocarbon mixture the ignition temperature of which is below 2500°F, provided the particle is of such size that it contains enough heat to raise a portion of the hydrocarbon mixture to its ignition temperature. By using the 1 to 5 spark temperature ratio between copper and steel, a spark temperature of 500°F could be attained with copper tools. Copper-nickel alloys with small amounts of iron could develop spark temperatures well above 500°F. These tools would thus be capable of igniting any combustible hydrocarbon mixture having an ignition temperature of 500°F or below. (Theoretically, then, it could be concluded that particles from copper-beryllium alloy hand tools could cause ignition of some hydrocarbon mixtures even though they do not become incandescent sparks.)

Effect of Particle Size

It has been found that particle size generally has a pronounced effect on spark ignition. Microscopic examination of particles produced in an inert gas atmosphere and in air, showed that the sparks from steel which would not ignite gasoline vapors were very small. Although such sparks were at temperatures of 2300–2500°F, the heat content of these smaller sparks was insufficient to cause ignition.

In the case of particles whose mass is theoretically large enough to cause ignition, the initial temperatures attained through friction or impact must be high enough to initiate rapid oxidation on the surface. If it is not, the large particles cool and do not ignite the vapor. Experiments have shown that by preheating soft iron by pressing it against a grinding stone, large metal particles can be obtained with high enough initial temperatures to cause rapid oxidation of the surface and thereby initiate and propagate flame in vapor-air mixtures. However, because of the small size of particles from steel hand tools the total energy content was too low to cause ignition.

Other experiments[1] showed that very small particles (less than 1 microgram for aluminum and magnesium), when electrically heated to their ignition temperatures, were effective in igniting methane-air mixtures. The minimum size of particles depended on the composition of the gas. It was also found that for the particular metals tested (aluminum, magnesium, titanium, zirconium, cerium, and thorium), their order of effectiveness was the same as the order of their heats of combustion. The particle size required for ignition decreased as the heat of combustion increased.

Impact Ignition

There are cases where ignition can result from impact alone (no oxidation reaction). Such ignitions are referred to as impact ignitions. An example is ignition resulting from contact between steel and siliceous sandstone. Experi-

ments are reported[2] in which ignitions were obtained with sharp glancing strokes of hand picks against sandstone. There were no showers of sparks through the flammable mixture, but rather, a localized yellow flash at the moment of impact and over the area of contact. When a shower of sparks did prevail, ignitions did not result. Tests with coal cutter picks set at the circumference of a rapidly revolving rock wheel ignited methane-air mixtures (firedamp) by heating the rock surfaces.

The exact mechanism of impact ignition is not yet agreed upon. Although many accept the belief that the hardness and the low thermal conductivity of the rock material are governing factors in this ignition process, that belief has not been wholly substantiated.

Effect of Coatings

It has been reported that hammers and tools of bronze, copper, aluminum, glass, and even rubber can strike sparks off aluminum-painted iron under certain conditions. Some of the conditions required for sparking are that the iron must be rusty and the painted surface must be heated to a temperature of 300–400°F. Once the painted surface has been heated, sparks reportedly can be struck from the paint whether it is hot or cold. Cracks in the paint film facilitate sparking. A thermit reaction between aluminum and rust has been advanced as a possible explanation of this reaction. This theory is supported by experiments which showed that a priming coat of red lead on the iron reduced the chances of sparking from aluminum-painted surfaces, but that when the red lead was added to the aluminum paint itself, a painted surface gave spark reactions which were almost explosive.

References

[1]Chemical Engineers Handbook. McGraw-Hill Book Co., New York, 1940.

[2]Explosives, Vol. III. A. Marshall. P. Blakiston's Son & Co., Philadelphia, 1932.

The Why of Growing U. S. Fire Losses

By J. H. Finnegan

Manager, Actuarial Bureau National Board of Fire Underwriters

Engineers and others in the fire prevention field have a much better than average appreciation of the time and effort devoted each year to fire prevention and protection activities. Yet, available statistics indicate that during recent years, fire losses in the United States have been increasing rapidly. Finding the loss total for any year to be lower than that for the previous year is the exception rather than the rule. For anyone to question just how effective have been these fire prevention and protection activities is thus not surprising.

For some years data have been compiled on the U. S. "national wealth." This term is used to describe the value each year of all land, buildings, equipment, contents, and other reproducible assets found in the United States. The latest series of national wealth figures appears in "A Study of Saving in the United States" by Goldsmith, Brady and Mendershausen.* The over-all national wealth totals from 1895 to 1950, with land, monetary gold stock, and government property deducted, are used in Figure A *unadjusted* for price changes. Figure A also has plotted, for comparison purposes, the figures from the National Board of Fire Underwriters on the annual fire losses from 1895 to 1958.† These also have *not* been adjusted for price changes. The national wealth curve has been plotted with all values divided by 1,000 to facilitate comparison with the curve for total estimated fire losses.

The first item to be noted from a study of Figure A is the similarity between the paths of the statistics on the national wealth and the national fire loss. It would, of course, be strange if there was no relationship since the more wealth on hand, the more wealth is exposed to fire.

A second conclusion from the comparison of the two curves is that the fire loss curve is higher than that for national wealth during the early years, that the two are quite close between 1933 and 1948, and that, for years since 1949, the fire loss curve appears lower. This is a rough visual indication that the relationship between the national fire losses and national wealth has changed since 1896.

For a clearer picture of what has happened, ratios of fire losses to national wealth for one nine-year period and for five successive ten-year periods are given in Table No. 1.

Table No. 1

PERCENTAGE OF THE NATIONAL FIRE LOSSES OF THE NATIONAL WEALTH

Years	*Per Cent*
1896 – 1904	0.3
1905 – 1914	0.3
1915 – 1924	0.2
1925 – 1934	0.2
1935 – 1944	0.1
1945 – 1954	0.1

Based on an address by the author at the 63rd NFPA Annual Meeting held June 1–5, 1959 at Atlantic City, New Jersey.

*Princeton University Press, Princeton, N. J., 1956, $8.50 per copy.

†NBFU loss estimates represent losses incurred in the Continental United States. These are lower than the NFPA over-all United States loss estimates which include allowances for forest, automobile and aircraft fires.

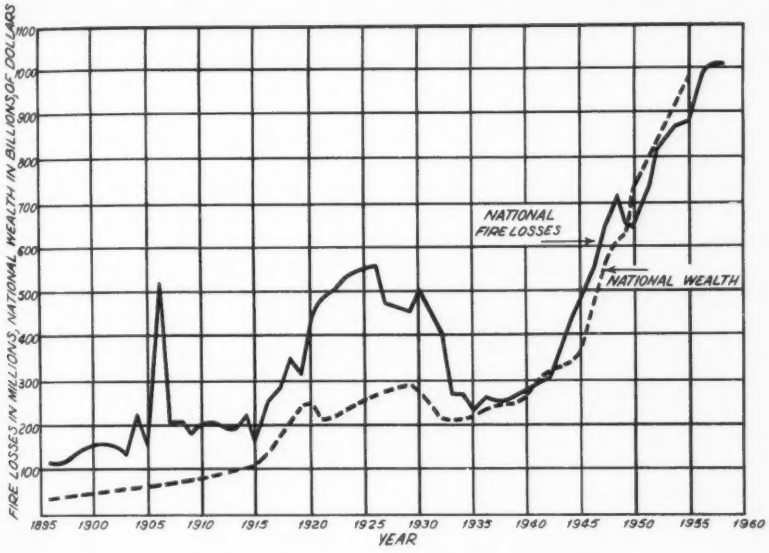

Figure A. National fire losses (in millions of dollars) compared with applicable national wealth figures (in billions of dollars), both unadjusted for price changes.

The 0.3 per cent on the first line means that three-tenths of one per cent of the national wealth in existence during 1896 to 1904 was destroyed by fire during that period. The other percentages refer to the decades shown.

These percentages indicate in a different way what Figure A shows: that during the period 1896 to date the proportion of the national wealth destroyed by fire has been *decreasing*. It may also be observed that the relative fire damage during the period 1896 to 1914 was three times the relative amount destroyed during more recent years.

These percentages may appear to be very small and the change insignificant. However, if the 1896 to 1904 ratio of 0.3 per cent had not declined and if that 0.3 per cent was applied to the national wealth figure for the year 1955, the hypothetical loss total for 1955 would have been $2,900,000,000. This is two billion dollars more than the actual NBFU fire loss estimate for that year. That this difference is enough to justify past and present fire prevention activities can hardly be denied!

Further reference to Figure A shows that there has been a rapid growth in the dollar value of both the national wealth and the national fire losses since 1935. This has been due to a number of factors but a study of price level changes makes it clear that most of the apparent growth in the national wealth since 1940 has been the result of rising prices. The indications are that the national fire loss curve, if adjusted for price changes, would follow the *adjusted* national wealth curve with approximately the same closeness as the *unadjusted* curves follow each other. From this it follows that a good part of the increase in fire losses since 1940 has been the result of price increases.

Turning now to the experience of the last few years, Table No. 2 gives the National Board of Fire Underwriters' estimated annual fire losses for 1954 to 1958 with the percentage by which each year's total is larger than that for the year before. These reveal that the percentages of increase in fire losses from year to year, with the exception of that for 1956 over 1955, have been between 2 per cent and 4 per cent and that the 1956 total was exceptional in that it was 12 per cent above the total for 1955. Special attention will now be given to this 1956 increase of $104,000,000 because it was so large and is probably the easiest to study.

Table No. 2

NBFU Annual Estimated Fire Losses 1954–1958

Year	*Estimated Fire Losses*	*Per Cent Change*
1954	$870,984,000	..
1955	885,218,000	2
1956	989,290,000	12
1957	1,023,190,000	4
1958	1,056,266,000	3

Reference to the NBFU's Actuarial Bureau data as to the size of the claims paid during 1956 reveals that fire insurance claims under $10,000 represented a dollar total which is 8 per cent above the corresponding figure for 1955. In 1956 claims from $10,000 to $249,999 amounted to a dollar total 12 per cent above that for 1955. In 1956 claims $250,000 and over accounted for a dollar total 22 per cent above that for 1955.

At first, the foregoing figures might be taken to mean that the $104,000,000 by which 1956 losses were larger than those for 1955 was due to payments for claims of $250,000 and over inasmuch as those claims were 22 per cent over 1955. This, however, would not be correct since the dollar value of the 22 per cent increase found for fires costing $250,000 and over is only about 10 per cent of the $104,000,000 total. The 12 per cent increase mentioned for payments between $10,000 and $249,999 represents $56,000,000 and the 8 per cent mentioned for payments under $10,000 accounts for the remaining $36,000,000. Stated in other words, the increase in losses which occurred in 1956 can be explained only by recognizing that there was an increase in dollars paid for claims of *all* sizes and that the payments of $250,000 and more, while not having the dominant effect on the total, did show the largest proportional growth.

The foregoing indicates that:

1. The national fire losses appear to grow with the national wealth.

2. Both the national wealth and the national fire losses are affected by price changes which have made both series appear to grow much faster than they actually have grown.

3. Losses during recent years have been growing rapidly. From the increase in 1956 over 1955, it appears that the increase occurred among the small sized claims as well as the large, but the largest appear to be growing faster.

4. The proportion of national wealth destroyed by fire has actually been *declining*, thereby indicating that fire prevention and protection activities have been and still are effective.

It is probably safe to say that a very small proportion of the fires which occur grow to be losses of $100,000 or more. The question of why these few fires grow to be large ones is the subject of a study which the National Board of Fire Underwriters has had underway for almost ten years. Results are now becoming meaningful and totals of the latest NBFU tabulations are shown in the report of the National Board's Committee on Statistics and Origin of Losses released in

May, 1959*. NFPA has also been making studies along the same lines and NFPA members are familiar with the annual large loss fire studies in the QUARTERLIES. The data are not to be analyzed at this time since for present purposes it seems sufficient to say that since 1954 close to 2,000 reports for fires of $100,000 or more have been examined by the National Board. From those reports it has been learned that a great many of the 2,000 fires were not discovered until they were well under way. Large undivided areas were found to have played an important part. Some form of water supply deficiency and highly combustible contents are among the other more important factors. Work already done reveals that a large fire is seldom if ever the result of one factor.

*Published by the National Board of Fire Underwriters, 85 John St., New York 38, N. Y.

Much of the "why" for fires which cause large losses is to be found among the factors just mentioned. More of the "why" is to be learned from a study of the causes which started the ignition and from an analysis of data on the materials which were in close proximity to the spark and began to burn when the ignition came. As the size of loss decreases, the factors lose some of their importance but they will, in all probability, be found to some degree in every loss of any size.

As indicated in the early part of this paper, fire prevention and protection, at least since 1896, have grown greatly in effectiveness. It is hoped that the explanations of the "why" offered herewith will help make fire prevention and protection more effective than ever before.

Fires and Fire Losses Classified, 1958

Editor's Note: During recent years NFPA members have called attention to instances where certain parts of this article, notably Table VI, have been taken out of context and misused in advertisements and otherwise. Readers are reminded that material published in the QUARTERLY is copyrighted and may not be reproduced in whole or in part without written permission from the Association. This article is available from the Association in pamphlet form.

There were approximately 1,993,575 fires of all types in the United States in 1958 causing a loss of $1,278,808,000, according to estimates compiled by the National Fire Protection Association. The 1958 loss was a slight decrease from that of 1957 when the estimated loss was $1,279,926,000. The 1,993,575 fires in 1958 were 31,925 fewer than in 1957.

Building fires in the U. S. in 1958 totaled 866,700 and caused $1,056,308,000 damage. An additional 1,126,875 fires not involving buildings — aircraft, motor vehicles, forests, ships, rubbish, grass fires, etc. — accounted for an estimated $222,500,000. Building fire estimates for 1957, reported in the October 1958 QUARTERLY, showed 843,900 fires with $1,068,115,000 loss.

One of the notable changes in the 1958 occupancy experience (Table V) from that of 1957 was in dwellings where there were 28,000 more fires and an increase of $32,750,000 in loss. Other substantial increases were in aircraft fires where the loss went up $28,000,000 and in office and bank buildings where there was a $17,995,000 increase. The favorable changes in the occupancy experience included a $56,768,000 decrease in manufacturing plant losses, an $18,962,000 decrease in store losses, and a $10,100,000 drop in garage losses.

Building fire losses by cause are estimated in Table VI. Principal changes in the 1958 experience involved incendiary or suspicious fires and fires attributed to careless smoking. Fires set or believed to have been set increased 40 per cent in number and $4,926,000 in total loss. There were 15 per cent more careless smoking fires, and the loss from such fires increased $1,310,000. Fires caused by sparks on roofs continued their downward trend, dropping to 9,300 in 1958. In 1948 the number of fires attributed to this cause was 23,500; in 1938, 63,000.

Methods of Compiling Data

The data from which Tables I to IV were compiled were obtained from 15 state fire marshals' reports for the year 1958 or the closest fiscal year thereto.

While the methods of reporting and tabulating fire loss figures differ from state to state, the volume of statistics from the 15 typical states chosen, representing all sections of the country and including both primarily agricultural and industrial states, is sufficiently large to indicate the relative distribution of fires and fire losses. Table I shows the number of fires by occupancy in 14 states and Table II the loss by occupancy in 12 states. Tables III and IV list the number of fires and loss by cause in 14 and 11 states respectively.

Tables V and VI, showing the nation-wide distribution of fires and losses by occupancy and cause, are based primarily on typical state experience enumerated in Tables I to IV. Table VII summarizes statistics from all state reports received.

(continued on page 168)

TABLE I. Number of Fires by Occupancies in Fourteen States — 1958

	Conn.[1]	Ill.[2]	Iowa	Kans.	Ky.	La.	Minn.[3]	Nebr.	N. H.	Ore.[4,5]	S. D.[1]	Vt.[4,5]	Wis.[4]	Wyo.	Totals
I. Public Buildings															
Amusement places, halls	10	74	16	4	19	...	26	21	5	...	6	14	76	5	276
Churches	6	75	19	11	45	91	19	5	7	43	6	10	81	4	422
Government buildings	3	5	4	...	24	...	...	2	4	34	2	5	40	1	124
Hospitals, institutions	2	24	11	7	5	39	18	4	2	...	2	5	26	1	146
Schools and colleges	16	61	13	16	27	54	19	9	7	56	9	14	106	2	409
Theatres, including motion picture	2	16	2	10	7	14	3	3	1	9	2	2	21m	1	93
II. Residential															
Apartments	142	1,977l	114	88	37l	...	208e	83e	62	...	14	12	207	13	2,957
Boarding and rooming houses	24	...	6a	9a	...	...	...	...	5	...	1	5	51	1	102
Dwellings	851	5,192	1,327	1,131	3,828	4,836	1,153	580	698	11,228f	509	520	24,719	543	57,115
Hotels	17	215k	23	32	25k	333i	49	19	15	314i	31g	38	129	4e	1,244
Motels, tourist cabins	...	...	6	13	...	...	8	2	2	...	10	4	50	1	96
III. Mercantile															
Offices, banks	16	118	18	15	25	423	42	11	2	...	7	6	91	8	782
Restaurants, taverns	49	376	77	56	62	...	72	24	17	120	6	12	615	16	1,502
Stores	118	848	159	228	157	...	256	41	55	414j	77h	90	67	14	2,524
Warehouses	21	123	27	56	11	57	83	18	3	40	...	5	140	13	597
IV. Manufacturing															
Bakeries	5	19	4	1	1	...	2	4	1	4	...	...	21	...	62
Cleaners, tailors	1	17	7	...	...	...	9	...	2	...	3	...	25	...	64
Food processing	...	5	3	6	13	32	...	6	1	37	2	3	2	1	111
Grain mills, elevators	...	56	20	19	9	9	33	23	2	17	6	...	47	4	245
Laundries	1	39	5	10b	13b	...	14	8b	1	31b	2	2	20	1	147
Metalworkers	6	18	17	13	6	14	14	...	1	13	1	3	95	4	205
Printing	3	...	7	5	7	...	...	1	...	5	2	3	22	...	55
Textileworkers	...	...	3	1	5	52	...	...	...	4	...	2	2	...	69
Woodworkers	3	105	19	5	11	16	...	...	10	155	...	5	15	...	344
Miscellaneous manufacturing	60	372	24	6	51	30	103	26	38	44	11	12	265	6	1,048
V. Miscellaneous Buildings															
Barns	121	261	187	378c	238	171	177	282c	35	278c	157	229c	1,282	...	3,796
Bulk oil storage, refining	1	18	...	2	11	58	6	10	...	24	...	...	...	...	130
Creameries and dairies	...	...	1	5	1	...	5	3	2	7	...	...	44	...	68
Garages	86	1,236	33	129d	39	8	36d	34	11	31	103d	14	378n	31	2,169
Lumber and coal yards	2	54	6	3	37	14	9	5	2	...	6	5	28	4	175
Outbuildings	...	...	212	1	81	...	456	116	113	...	6	1	4,015	71	5,072
Piers, including shipyards	1	...	...	...	3	...	...	...	...	...	...	...	...	...	4
Power plants, pump houses	...	21	14	1	7	...	12	...	6	29	4	...	60	...	154
Railroad property, including rolling stock	...	19	14	15	1	39	20	12	1	...	9	...	82	5	217
Service stations (see also garages)	7	95	27	...	...	...	...	...	7	...	...	2	48	5	191
Miscellaneous other structures	15	1,022	245	2	16	19	44	12	3	18	2	2	66	...	1,540
VI. Other Than Building Fires															
Aircraft	...	1	2	1	...	...	4	...	...	...	...	...	...	1	9
Forest fires	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Motor vehicles	172	2,104	441	411	...	757	176	323	...	462	229	...	2,537	70	7,682
Rubbish, grass, brush	...	...	13	...	2	...	...	216	...	...	...	...	...	394	625
Miscellaneous	201	425	139	2	173	...	102	18	2	5	297	...	991	38	2,393
Totals	1,962	14,991	3,265	2,692	4,997	7,140	3,178	1,921	1,123	13,422	1,522	1,025	36,464	1,262	94,964

[1] Fiscal year ended June 30, 1959.
[2] Fiscal year ended June 30, 1958.
[3] No losses less than $25.
[4] Insured losses only.
[5] Number of insurance claims.

a. Includes fraternity and sorority houses.
b. Includes dry cleaners.
c. Includes all farm property.
d. Includes service stations.
e. Includes rooming houses.
f. Includes apartments.
g. Includes restaurants.
h. Includes warehouses.
i. Includes motels.
j. Includes office buildings.
k. Includes boarding houses.
l. Includes flats and rooming houses.
m. Includes halls.
n. Includes hangars.

TABLE II. Fire Losses by Occupancies in Twelve States — 1958

Losses were reported by the states to the nearest dollar. They are reported in thousands in this table.

	Conn.[1]	Illinois[2]	Iowa	Kansas	Kentucky	Louisiana	Minn.[3]	Nebraska	Oregon[4]	S. D.[1]	Vt.[4]	Wis.[4]	Totals
I. Public Buildings													
Amusement places, halls	$ 26.9	$ 1,208.0	$ 549.4	$ 6.9	$ 121.7	$	$ 238.7	$ 34.2	$	$ 35.4	$ 41.4	$ 329.6	$ 2,592.2
Churches	248.3	621.2	336.2	31.0	359.4	241.4	204.1	29.1	114.9	141.4	20.6	413.2	2,760.8
Government buildings	11.4	0.5	2.1	.....	347.2	.....	.....	1.2	18.0	0.3	2.2	9.4	392.3
Hospitals, institutions	4.0	27.5	81.0	0.9	2.1	61.2	5.9	11.3	.....	0.3	6.0	20.0	220.2
Schools and colleges	116.1	702.8	77.4	30.8	284.7	875.2	627.6	23.4	651.2	222.1	97.3	345.1	4,053.7
Theatres, including motion picture	10.5	225.9	149.5	42.0	2.7	205.5	24.2	37.5	30.0	0.3	16.9	119.9m	864.9
II. Residential													
Apartments	456.6	3,615.7l	115.0	27.0	167.7l	.....	497.7e	101.7e	.....	17.2	12.1	126.7	5,137.4
Boarding and rooming houses	110.5	.....	1.3a	1.1a	.....	.....	.....	.....	.....	0.5	4.5	32.6	150.5
Dwellings	2,504.3	9,465.0	2,864.0	1,055.0	8,863.2	6,045.9	2,808.4	1,147.2	5,743.5f	521.8	742.6	7,676.3	49,437.2
Hotels	139.9	768.1k	21.2	26.2	84.4k	667.2i	210.9	28.8	330.0i	69.1g	97.1	85.9	2,528.8
Motels, tourist cabins	.....	.....	5.3	17.3	.....	.....	10.3	0.7	.....	4.2	8.9	18.4	65.1
III. Mercantile													
Offices, banks	170.8	500.3	268.6	43.5	62.6	2,206.8	127.2	34.0	.....	20.4	27.1	38.7	3,500.0
Restaurants, taverns	317.4	1,592.0	334.0	78.0	145.2	.....	354.0	150.2	226.3	27.8	74.0	1,118.5	4,417.4
Stores	566.8	4,298.3	2,341.6	872.2	1,186.2	.....	2,024.0	314.2	1,486.0j	282.7h	558.0	30.2	13,960.2
Warehouses	472.1	1,059.9	219.2	377.8	145.2	605.6	1,063.6	543.4	227.9	.....	81.7	1,216.8	6,013.2
IV. Manufacturing													
Bakeries	0.6	46.0	11.1	0.1	0.1	.....	0.2	18.3	6.3	.....	.....	7.2	89.9
Cleaners, tailors	3.0	41.9	6.0	.....	.....	.....	45.5	.....	.....	0.4	.....	61.4	158.2
Food processing	.....	4.7	1.8	34.0	299.4	195.6	.....	3.5	238.1	1.3	2.3	2.9	783.6
Grain mills, elevators	.....	89.8	406.9	236.0	31.1	22.7	549.0	673.6	437.4	66.7	.....	186.7	2,699.9
Laundries	3.4	208.4	1.0	2.0b	20.0b	.....	34.6	10.4b	82.6b	0.1	4.9	5.3	372.7
Metalworkers	79.0	155.2	112.6	26.5	48.9	44.0	86.0	.....	18.3	112.0	4.7	883.3	1,570.5
Printing	1.4	.....	7.8	39.0	69.9	.....	.....	0.4	0.9	7.7	65.9	180.1	373.1
Textileworkers	.....	.....	13.3	0.3	28.6	248.7	.....	.....	5.3	.....	0.6	9.5	306.3
Woodworkers	20.3	1,466.5	252.7	27.6	127.9	52.2	.....	.....	1,557.6	.....	38.6	42.2	3,585.6
Miscellaneous manufacturing	817.7	5,912.4	123.2	21.8	2,111.7	598.7	1,240.3	51.0	95.4	13.9	20.0	1,844.3	12,850.4
V. Miscellaneous Buildings													
Barns	539.3	1,735.6	1,300.9	855.5c	678.5	334.0	1,109.4	717.3c	737.9c	486.8	782.8c	3,560.3	12,838.3
Bulk oil storage, refining	0.1	84.3	.....	2.2	59.8	3,115.4	45.0	130.9	57.1	.....	.....	.....	3,454.8
Creameries and dairies	.....	.....	1.0	1.8	0.4	.....	1.7	0.7	26.0	.....	.....	74.5	106.1
Garages	339.1	1,596.8	237.9	204.4d	194.7	58.3	172.5d	76.4	165.9	241.6d	43.8	405.7n	3,737.1
Lumber and coal yards	9.4	613.3	212.4	120.0	659.3	112.6	295.2	223.1	.....	111.2	115.9	100.7	2,573.1
Outbuildings	.....	.....	440.7	2.0	114.5	.....	454.1	93.4	.....	1.4	0.7	791.5	1,898.3
Piers, including shipyards	2.0	.....	.. ..	.....	8.0	.....	.....	.....	.....	.....	.....	.....	10.0
Power plants, pump houses	.....	31.2	10.3	0.1	13.3	.....	21.3	.....	222.3	28.3	.....	78.1	404.9
Railroad property, including rolling stock	.....	784.9	118.9	23.1	3.4	71.1	13.6	62.3	.....	314.3	.....	36.0	1,427.6
Service stations (see also garages)	48.8	203.4	66.6	.....	.....	.....	.....	.....	.....	.....	5.6	19.5	343.9
Miscellaneous other structures	211.7	2,195.7	271.6	0.1	19.1	688.3	82.0	263.3	147.9	1.1	0.9	57.6	3,939.3
VI. Other Than Building Fires													
Aircraft	.....	1,000.0	7.0	2.0	.....	.....	4,090.6	.....	.....	.....	.....	.....	5,099.6
Forest fires	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Motor vehicles	78.1	976.1	226.0	95.8	.....	292.8	166.9	502.8	104.1	84.9	.....	386.2	2,913.7
Rubbish, grass, brush	.....	.....	14.0	.....	0.9	.....	.....	113.1	.....	.....	.....	.....	128.0
Miscellaneous	1,355.7	743.8	206.0	1.3	116.4	.....	155.2	29.7	25.8	149.5	.....	3,224.5	6,007.9
Totals	$8,665.2	$41,975.2	$11,415.5	$4,305.3	$16,378.2	$16,743.2	$16,759.7	$5,427.1	$12,756.7	$2,964.7	$2,877.1	$23,538.8	$163,806.7

[1] Fiscal year ended June 30, 1959.
[2] Fiscal year ended June 30, 1958.
[3] No losses less than $25.
[4] Insured losses only.

a. Includes fraternity and sorority houses.
b. Includes dry cleaners.
c. Includes all farm property.
d. Includes service stations.
e. Includes rooming houses.
f. Includes apartments.
g. Includes restaurants.
h. Includes warehouses.
i. Includes motels.
j. Includes office buildings.
k. Includes boarding houses.
l. Includes flats and rooming houses.
m. Includes halls.
n. Includes hangars.

TABLE III. Number of Fires by Causes in Fourteen States — 1958

	Conn.[1]	Ill.[2]	Iowa	Kans.	Ky.	La.	Nebr.	N. H.	Ore.[3,4]	R. I.[5]	S. D.[1]	Vt.[3,4]	Wis.[3]	Wyo.	Totals
Heating and cooking (See also Flammable liquid appliances; gas and appliances)															
Oil-fired equipment defective or overheated	138	...	68	...	...	96	...	76	...	49	11	69	341	...	848
Gas-fired equipment defective or overheated	...	...	26	...	...	314	...	3	...	...	...	...	...	...	343
Other equipment, incl. solid fuels, and unknown types	58	1,205	195	225	444	48	151	142	788	87	116	71	1,429	73	5,032
Chimneys, flues defective or overheated	48	546	101	55	614	82	55	114	681	48	38	122	1,520	24	4,048
Hot ashes and coals	11	318	24	37	58	...	8	4	940	2	2	17	105	62	1,588
Combustibles near heaters	2	83	95	...	...	...	24	7	...	...	...	...	537	16	764
Smoking and matches	286	3,077	367	244	426	887	190	163	3,163[1]	81	162	96	7,241	114	16,497
Electrical															
Fixed services, fires due to wiring, equipment, etc.	150	1,853	272	349	752	995a	222	100	905	151	183	106	2,954	142	9,134
Power consuming appliances	117	448	194	8	106	...	106	88	2,051	...	91	1	2,493	80	5,783
Rubbish, source of ignition unknown	37	1,572	...	108	54	...	154	22	35	9	114	...	204	288	2,597
Flammable liquids															
Appliances, incl. lamps, blow torches, etc.	17	...	25	...	...	...	6	9	...	...	42	...	86	6	191
Miscellaneous other flammable liquid fires	66	524	132	200	259	...	175	95	2,239	58	85	56	1,972	121	5,982
Open flames and sparks															
Sparks on roof	6	171	68	11	15	...	...	...	144	...	1	4	...	...	420
Welding and cutting	...	...	38	...	...	37	29	22	...	...	9	...	128	4	267
Sparks from machinery, friction	...	449	20	9	18	31	20	17	25	...	...	6	56	...	651
Thawing pipes	1	...	18	...	...	...	9	11	...	...	4	...	24	...	67
Miscellaneous open flames and sparks	41	631	229	71	65	858	118	2	102	42	176	12	995	27	3,369
Lightning	56	110	60	52	412	506	98	78	298	16	67	61	11,983	19	13,816
Children and matches	100	...	157	...	...	...	97	47	220	72	78	15	601	9	1,396
Exposure	18	808	169	112	105	475	36	21	663	13	9	78	453	53	3,013
Incendiary, suspicious	73	155	21	17	49	135	16	22	132	68	5	2	114	16	825
Spontaneous ignition	...	312	79	20	44	22	55	19	91	16	42	11	249	21	981
Gas and appliances, incl. gas explosions	23	277	30	38	29	...	21	11	...	15	12	5	90	30	581
Explosions, miscellaneous and unclassified	3	100	...	48	106	...	4	...	55	...	33	3	900	7	1,259
Miscellaneous known causes	467	650	343	178	5	224	57	15	49b	190	98	76	394	69	2,815
Unknown or undetermined	244	1,702	534	910	1,436	2,430	270	35	841	188	144	214	1,595	81	10,624
Totals	1,962	14,991	3,265	2,692	4,997	7,140	1,921	1,123	13,422	1,105	1,522	1,025	36,464	1,262	92,891

[1] Fiscal year ended June 30, 1959.
[2] Fiscal year ended June 30, 1958.
[3] Insured losses only.
[4] Number of insurance claims.
[5] Fiscal year ended September 30, 1958.

a. Includes electrical power consuming appliances.
b. Includes four fires caused by amateur rockets.

TABLE IV. Fire Losses by Causes in Eleven States — 1958

Losses were reported by the states to the nearest dollar. They are reported in thousands in this table.

	Conn.[1]	Illinois[2]	Iowa	Kansas	Kentucky	Louisiana	Nebraska	Oregon[3]	S. D.[1]	Vermont[3]	Wis.[3]	Totals
Heating and cooking (See also Flammable liquid appliances; gas and appliances)												
Oil-fired equipment defective or overheated	$ 412.8	$	$ 211.7	$	$	$ 142.9	$	$	$ 7.1	$ 152.2	$ 191.7	$ 1,118.4
Gas-fired equipment defective or overheated	.....	.....	51.6	.....	.....	529.6	.....	.....	.....	.....	.....	581.2
Other equipment, incl. solid fuels, and unknown types	150.7	2,392.6	393.0	440.2	1,534.0	45.8	294.6	837.1	156.1	137.7	1,401.9	7,783.7
Chimneys, flues defective or overheated	63.3	1,035.8	174.3	75.8	1,676.6	95.0	67.6	620.8	36.3	113.7	961.5	4,920.7
Hot ashes and coals	13.3	360.3	78.4	11.6	54.4	.....	3.3	395.1	0.8	16.1	64.9	998.2
Combustibles near heaters	6.5	76.7	208.5	.....	.....	.....	28.0	.....	.....	.....	119.4	439.1
Smoking and matches	780.7	3,499.4	319.9	89.7	868.2	405.8	256.2	630.9	92.7	81.0	1,709.6	8,734.1
Electrical												
Fixed services, fires due to wiring, equipment, etc.	795.8	4,556.7	1,352.3	515.5	4,247.0	1,761.1a	588.8	2,131.9	338.1	435.1	5,858.4	22,580.7
Power consuming appliances	197.3	820.4	332.5	5.7	127.0	.....	365.7	575.9	154.2	0.2	1,074.4	3,653.3
Rubbish, source of ignition unknown	53.3	3,174.4	.....	24.8	49.3	.....	133.1	35.3	38.9	.....	113.3	3,622.4
Flammable liquids												
Appliances, incl. lamps, blow torches, etc.	42.8	.....	40.0	.....	.....	.....	22.4	.....	97.1	.....	30.4	232.7
Miscellaneous other flammable liquid fires	354.4	1,228.5	365.5	255.7	418.6	.....	222.1	398.3	125.4	21.4	430.5	3,820.4
Open flames and sparks												
Sparks on roof	7.2	214.3	116.5	2.2	39.4	.....	.....	129.7	0.1	3.8	.....	513.2
Welding and cutting	.....	.....	95.7	.....	.....	116.4	32.1	.....	33.1	.....	278.3	555.6
Sparks from machinery, friction	.....	881.4	20.7	2.0	35.3	61.6	64.4	139.0	.....	20.7	16.6	1,241.7
Thawing pipes	3.5	.....	34.6	.....	.....	.....	28.3	.....	7.9	.....	45.8	119.5
Miscellaneous open flames and sparks	42.5	1,078.3	236.9	65.6	153.1	1,039.9	123.3	25.4	226.9	23.7	972.4	3,988.0
Lightning	189.3	540.1	541.4	175.0	498.8	251.2	335.7	143.3	67.0	53.6	1,757.3	4,552.7
Children and matches	275.4	.....	135.8	.....	.....	.....	123.5	186.8	76.4	14.2	591.1	1,403.2
Exposure	225.1	1,271.6	1,228.3	81.4	158.1	1,207.6	69.5	759.4	57.4	295.4	300.4	5,654.2
Incendiary, suspicious	373.1	414.4	65.5	39.2	127.2	282.2	95.0	563.4	135.9	2.4	662.7	2,761.0
Spontaneous ignition	.....	1,085.2	295.7	32.0	97.5	59.2	120.7	313.7	129.7	42.0	1,001.3	3,177.0
Gas and appliances, incl. gas explosions	73.3	744.9	108.1	27.3	162.7	.....	133.6	.....	7.4	1.4	37.3	1,296.0
Explosions, miscellaneous and unclassified	88.8	2,342.7	.....	26.9	155.7	.....	2.3	89.2	151.7	1.2	990.0	3,848.5
Miscellaneous known causes	1,827.1	3,105.5	478.2	121.5	3.0	100.9	164.4	209.2b	139.6	141.8	292.3	6,583.5
Unknown or undetermined	2,689.0	13,152.0	4,531.0	2,313.2	5,972.3	10,644.0	2,152.5	4,572.3	884.9	1,319.5	4,637.3	52,868.0
Totals	$8,665.2	$41,975.2	$11,415.5	$4,305.3	$16,378.2	$16,743.2	$5,427.1	$12,756.7	$2,964.7	$2,877.1	$23,538.8	$147,047.0

[1] Fiscal year ended June 30, 1959.
[2] Fiscal year ended June 30, 1958.
[3] Insured losses only.

a. Includes electrical power consuming appliances.
b. Includes $6,211 loss from fires caused by amateur rockets.

Table V. Estimated Distribution of U. S. Fire Losses by Occupancies, 1958

These estimated figures are intended to show the relative order of magnitude of fire losses by occupancies, and while they are reasonable approximations based on the experience in typical states, they should not be taken as exact records for each class. As explained in the text, 100 per cent has been added in estimating the number of fires, and 33⅓ per cent has been added to the losses to cover unreported losses.

	No. of Fires		Losses	
I. Public Buildings				
Amusement places, halls	3,000		$18,098,500	
Churches	4,200		18,166,000	
Government buildings	1,700		4,010,000	
Hospitals, institutions	1,600		2,040,000	
Schools and colleges	4,000		23,981,000	
Theatres including motion picture	1,100	15,600	6,160,000	$ 72,455,500
II. Residential				
Apartments	34,900		33,272,500	
Boarding and rooming houses	5,100		3,907,000	
Dwellings	558,000		309,000,000	
Hotels	12,300		17,717,000	
Motels, tourist cabins	1,900	612,200	865,000	364,761,500
III. Mercantile				
Offices, banks	8,500		25,874,000	
Restaurants, taverns	17,400		29,057,000	
Stores	37,200		94,678,000	
Warehouses	6,100	69,200	42,635,000	192,244,000
IV. Manufacturing				
Bakeries	700		1,716,000	
Cleaners, tailors	1,400		1,775,000	
Food processing	2,300		8,536,500	
Grain mills, elevators	3,200		31,330,500	
Laundries	1,700		3,329,000	
Metalworkers	2,900		22,988,000	
Printing	1,100		5,663,000	
Textileworkers	7,500		8,001,000	
Woodworkers	4,300		29,372,000	
Miscellaneous manufacturing	13,300	38,400	62,561,000	175,272,000
V. Miscellaneous Buildings				
Barns	35,300		79,700,000	
Bulk oil storage, refining	1,800		16,530,000	
Creameries and dairies	1,600		4,000,000	
Garages	20,900		23,100,000	
Lumber and coal yards	1,800		17,384,000	
Outbuildings	30,200		25,800,000	
Piers, including shipyards	1,700		10,800,000	
Power plants, pump houses	2,500		3,690,000	
Railroad property, incl. rolling stock	4,700		14,965,500	
Service stations	3,600		4,000,000	
Miscellaneous other structures	27,200	131,300	51,605,500	251,575,000
Total (Building Fires)		866,700		$1,056,308,000
VI. Other Than Building Fires				
Aircraft	175		143,000,000	
Forest fires	97,900		24,500,000	
Motor vehicles	173,000		18,700,000	
Rubbish, grass, brush	810,000		.....	
Miscellaneous	45,800	1,126,875	36,300,000	222,500,000
Grand Total		1,993,575		$1,278,808,000

Various sources have furnished figures for items in Table V. Railroad losses were furnished by the Association of American Railroads, Fire Protection and Insurance Section. Statistics on aircraft fires were compiled by reference to the NFPA aircraft fire loss records. Motor vehicle and rubbish, grass, and brush fire data are based on the annual NFPA survey of U. S. cities (Fire Record

Table VI. Estimated U. S. Building Fire Losses by Causes, 1958

These estimated figures are intended to show the relative order of magnitude of fire losses by causes, and to indicate year-to-year trends. While they are reasonable approximations based on the experience in typical states, they should not be taken as exact records for each class. These figures by themselves do not show the relative safety in utilization of various types of material, devices, fuels or services and should not be used for this purpose. Reproduction of this Table in whole or part is not authorized without written permission from the Association.

	No. of Fires		Losses	
Heating and cooking (See also Flammable liquid appliances; gas and appliances)		193,000		$ 149,158,000
Oil-fired equipment defective or overheated	54,800		$36,038,000	
Gas-fired equipment defective or overheated	15,000		12,320,000	
Other equipment, incl. solid fuels, and unknown types	52,000		56,792,000	
Chimneys, flues defective or overheated	41,700		29,555,000	
Hot ashes and coals	17,100		7,970,000	
Combustibles near heaters	12,400		6,483,000	
Smoking and matches		150,000		70,590,000
Electrical		117,100		183,499,000
Fixed services, fires due to wiring, equipment, etc.	72,500		125,207,000	
Power consuming appliances	44,600		58,292,000	
Rubbish, source of ignition unknown		57,900		22,984,000
Flammable liquids		53,500		49,985,000
Appliances, incl. lamps, blow torches, etc.	5,400		6,460,000	
Miscellaneous other flammable liquid fires	48,100		43,525,000	
Open flames and sparks		52,500		66,424,000
Sparks on roof	9,300		5,619,000	
Welding and cutting	5,700		12,283,000	
Sparks from machinery, friction	5,700		16,116,000	
Thawing pipes	3,000		3,412,000	
Miscellaneous open flames and sparks	28,800		28,994,000	
Lightning		33,400		31,594,000
Children and matches		31,600		21,365,000
Exposure		26,100		31,460,000
Incendiary, suspicious		21,000		31,656,000
Spontaneous ignition		20,900		27,171,000
Gas and appliances, incl. gas explosions		10,000		9,647,000
Explosions, miscellaneous and unclassified		6,500		25,178,000
Miscellaneous known causes		29,000		47,764,000
Unknown or undetermined		64,200		287,833,000
Totals		866,700		$1,056,308,000

of Cities, April, 1959 QUARTERLY). The estimate of the number of forest fires was compiled by the Forest Service of the United States Department of Agriculture.

As will be seen in Table VII, 16 states with a population of 41,862,000 reported a total of 107,551 fires. Experience indicates that this is less than half the actual number of fires in these states. Some states, for example, do not report fires with uninsured losses, others report only fires with losses in excess of $25.

To obtain national estimates of the number of fires by occupancy 100 per cent was added to the number reported by the 14 states shown in Table I. Making use of this figure and population ratios, the number of fires by occupancy in the United States was calculated. Further adjustments were made based upon other surveys of 1958 fire experience. Following a similar procedure with the state experience shown in Table III, national estimates of the numbers of fires by cause were obtained.

To obtain the estimated national fire loss by occupancy and cause, the population ratio was applied to the loss of the states shown in Tables II and IV. To account for losses not reported through the usual channels, 33⅓ per cent was added as in the previous years. Further adjustment was necessary in a few instances because of unusually large damage in individual fires.

Table VII. Fires per 1000 Population and Fire Loss per Person for Sixteen States 1958, as Reported by Fire Marshals

State	Population 1959 Est.	No. of Fires	Fires Per 1000 Pop.	Fire Loss	Fire Loss Per Person
Connecticut[1]	2,339,000	1,962	0.84	$ 8,665,190	$3.71
Illinois[2]	9,977,000	14,991	1.50	41,975,200	4.21
Iowa	2,835,000	3,265	1.15	11,415,500	4.03
Kansas	2,130,000	2,692	1.26	2,692,000	1.26
Kentucky	3,089,000	4,997	1.61	16,378,200	5.30
Louisiana	3,142,000	7,140	2.27	16,743,200	5.33
Massachusetts	4,863,000	10,765	2.21	35,770,358	7.34
Minnesota[3]	3,401,000	3,178	0.93	16,759,700	4.92
Nebraska	1,465,000	1,921	1.32	5,427,100	3.70
New Hampshire	587,000	1,123	1.91	3,893,600	6.64
Oregon[4,5]	1,788,000	13,422	7.51	12,756,700	7.13
Rhode Island[6]	879,000	1,822	2.08	4,603,000	5.24
South Dakota[1]	702,000	1,522	2.17	2,964,700	4.22
Vermont[4,5]	371,000	1,025	2.76	2,877,100	7.74
Wisconsin[4]	3,972,000	36,464	9.18	23,538,800	5.93
Wyoming	322,000	1,262	3.92	1,021,000	3.18
	41,862,000	107,551	2.57	$207,481,348	$4.95

[1] Fiscal year ended June 30, 1959.
[2] Fiscal year ended June 30, 1958.
[3] No losses less than $25.
[4] Insured losses only.
[5] Number of insurance claims.
[6] Fiscal year ended September 30, 1958.

Bonding and Grounding Conference

By L. S. Inskip

Chairman, Panel No. 5 National Electrical Code Committee
Member, NFPA Committee on Lightning Protection

A conference was held in Pittsburgh, Pennsylvania, on November 17, 1958, attended by representatives of various NFPA committees having an interest in bonding and grounding.* The meeting was arranged by the NFPA headquarters at the suggestion of the National Electrical Code Panel 5 which is responsible for the rules on bonding and grounding of electric power installations. The primary objective of the conference was to review the special problems of bonding and grounding that arise because of the existence of several electric and nonelectric systems in a building.

Bonding vs. Grounding

One of the first items covered was a discussion of the terms "bonding" and "grounding." Attention was called to the fact that they have been used rather indiscriminately and suggestions were made that they should be used more exactly. Bonding should refer only to the electrical interconnection of objects to prevent differences in potential between them. Grounding should refer only to the electrical connection between an object and ground. While both bonding and grounding may be needed in certain situations, it is important to distinguish between the two. Where everything is grounded with connections of sufficiently low resistance, all objects are automatically at approximately the same potential, although this relationship may be disturbed by any substantial current flows.

The requirements for grounding vary depending on the purpose of the grounding. The housing of a portable tool, for example, is ordinarily grounded by connecting through a grounding conductor to the receptacle and from there over the conduit or the armor of armored cable back to the secondary neutral at the service equipment. A fault to the tool housing will cause fault current to flow out on the energized conductor and back on the grounding conductor until the overcurrent protection device operates. The fault current thus flows over a metallic path without flowing through the ground electrode, so that the electrode resistance is not involved. On the other hand, where the situation involves a contact of a primary power wire with a secondary wire all or a portion of the fault current, depending on the type of power system, will flow to ground through the ground electrode. A low resistance to ground will, of course, hasten the de-energization of the power system and minimize the momentary rise of potential on the secondary wiring. Bonding of the secondary neutral to other metallic systems will eliminate this momentary difference of potential between them.

Static Bonding and Grounding

Bonds and grounds for the elimination of static electricity can have a much higher resistance. All that is necessary is conductivity sufficient to carry off charges at a rate such that they will not build up to sparking potentials. For static electricity, bonding *may* be all that is needed although grounding is also frequently employed.

*This is a brief, general summary of the discussions at the informal meeting. No verbatim record was made of the proceedings since the meeting was intended only to explore the problems involved and to exchange thoughts.

Lightning Grounds

Lightning grounds present still different considerations. Here the wave shape of the discharge makes the path and length of the ground wire important and the large current makes it important to have adequate current carrying capacity. The actual resistance to ground of the ground electrode is not important provided all metallic bodies, wires and pipes of significant size or vulnerability to lightning damage are bonded to this same electrode.

Interconnecting Conductive Materials

It was emphasized that in modern construction with the multiplicity of pipes, wires, ducts, etc., all of conductive materials, accidental grounds are quite likely and it is practically impossible to keep each system completely separate from the others. There is always a possibility of trouble where the systems are not interconnected. For example, gas ranges with electric outlets and control mechanism provide a point of contact between gas systems and electric systems which pertains not only to the gas range itself but may result in interconnecting of the entire piping system with the wiring system and can cause trouble where the two are not interconnected.

Lightning may strike exposed liquefied petroleum gas cylinders, for example, and thus be conducted into the building and jump short distances to electrical equipment or other wires or pipes.

The general opinion seemed to be that a complete interconnection between the grounded portions of different systems is highly desirable.

Responsibility for Interconnection

Some difficulties may be encountered in respect to the grounding and bonding practices where one system is installed first and another system installed later. The responsibility for the interconnection should presumably rest with the installer of the second system although this may involve difficulties in actual practice. Where all systems are installed simultaneously, the responsibility for interconnection is far from clear but is nevertheless very important.

Nonconducting Pipe and Insulating Joints

One complicating factor in using gas piping and similar piping or ducts is the lack of electrical continuity. Where nonconducting pipe is used, where there are insulating joints, or even where a meter may be removed, the value of the ground is lost and a hazard may be introduced. Some gas companies provide bonds around the meter for the purpose of protecting personnel after some cases of serious electric shock to meter repair men.

The use of plastic pipe in services is another complicating factor. Even though a piping system within a building may be metallic, its value as a ground is lost if the service to the building from the street main is plastic.

Stray currents present another problem and may originate entirely outside of the building. There is a desire to protect buried piping against stray currents through using insulating joints or by covering the buried piping with an insulating material.

Bonding Adjacent Grounded Structures

As an illustration of the value of bonding independently grounded structures in close proximity, a case was mentioned of a man who was electrocuted when he stepped from a pier to a ship, thereby completing the circuit between the two grounds. While the pier and the ship were both grounded by contact with the water, the resist-

ance of one or both grounds was high enough to permit a hazardous potential to exist between them when one or the other ground became energized through a fault. Bonding would have prevented the hazard.

Static Charges on Nonconductors

One problem not touched on at the conference was the discharge of static electrical charges which accumulate on nonconductors. This is a special problem requiring various protective measures which were not discussed during the conference.

Those attending the meeting included the following representatives of the listed NFPA Committees:

L. S. Inskip, NFPA Committee on Lightning Protection
C. M. Blaesi, NFPA Committees on Blower Systems and Dust Explosion Hazards
J. J. Brenneman, NFPA Committee on Aviation
C. H. Bunn, Jr., NFPA Committee on Flammable Liquids
J. J. Duggan, NFPA Committees on Flammable Liquids and on Inerting for Fire and Explosion Prevention
C. W. Falls, NFPA Committee on Dust Explosion Hazards
Paul G. Guest, NFPA Committee on Static Electricity
R. M. Hill, NFPA Committees on Chemicals and Explosives, Flammable Liquids, Gases
Clark F. Jones, NFPA Committees on Gases and Hospital Operating Rooms
Robert Loeser, NFPA Committee on Marine Fire Protection
E. O. Mattocks, NFPA Committees on Internal Combustion Engines and Gases
J. F. McKenna, NFPA Committees on Flammable Liquids, Lightning, Static Electricity
J. A. O'Donnell, NFPA Committee on Aviation
C. M. Park, NFPA Committees on Dust Explosion Hazards and Lightning Protection
W. G. Schultz, NFPA Committee on Trailers and Trailer Camps
Frank Stetka, NFPA Electrical Section
M. E. Woodworth, NFPA Committee on Flammable Liquids
W. N. Zippler, NFPA Committee on Marine Fire Protection

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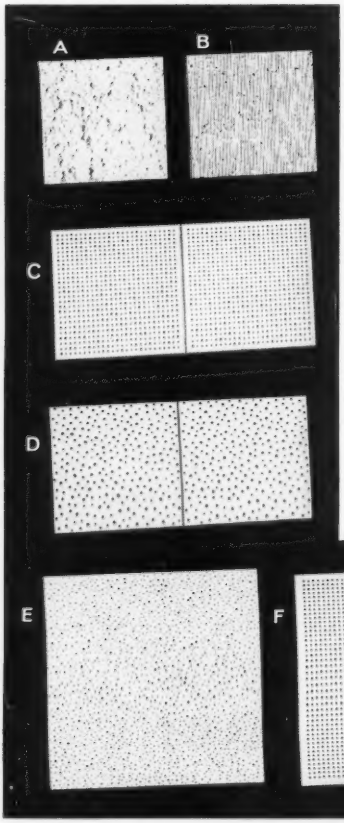

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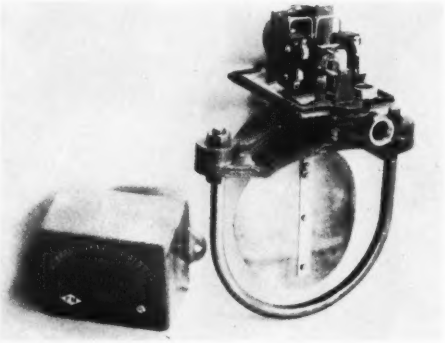


Model PRS-1

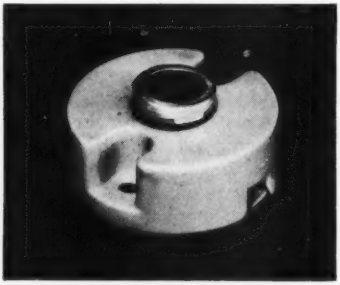
Sprinkler Waterflow Alarm

This device is approved by Factory Mutual Laboratories and Underwriters' Laboratories, Inc.

- This device is also made as Model PRT-1, a coded waterflow transmitter.

5-inch size shown above. To install simply drill 2-inch hole in pipe.

- Also made in explosion proof models.
- Made in all sizes from 2½" to 8".
- Has instantly recycling pneumatic retarding device, preventing false alarms.
- Has enclosed electrical contacts for any voltage not exceeding 15 amp. 125 volts, A.C. and ½ amp. 125 volts, D.C. Operates on all water pressures or surges.



Size is 1⅝" x ⅝"

Tempo-Set Model A Fire Detector

Underwriters' Laboratories, Inc. Approved.

- Self restoring and can be heat tested.
- Electrical contacts are silver or gold and are enclosed.
- Very reasonable price.

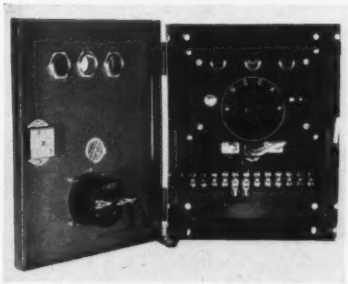
- Tempo-set Model A is approved in either open or closed circuit and the temperature ratings are 135 and 200 degrees.
- Approved maximum distance between thermostats on smooth ceilings: 20 feet.
- Electric ratings are 125 volts 1 ampere, A.C. or 24 volts 0.5 ampere D.C. or less.

CENTRAL STATION SIGNALS, INC.

53 WEST 23rd STREET . . . . NEW YORK 10, N.Y.

Proprietary & Remote Panels For Fire Headquarters

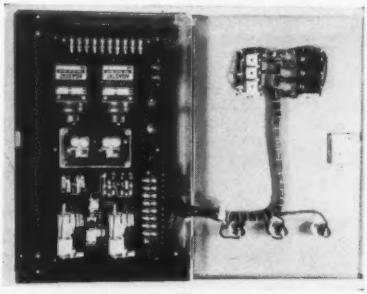
This Fire Headquarters Unit is designed to be used primarily for the receipt of signals at a remote station when actuated by a local alarm unit in the protected premises. It is electrically supervised and will give a trouble signal in case of open and ground and will also receive an alarm under these conditions. This panel is made for 12 or 24 volt D.C. operation.



Local Non-Coded Fire Headquarters Unit

Automatic McCulloh Class A Proprietary Panel

This single circuit panel is mounted in a red metal cabinet 18 x 12 x 6 inches, with switches and lights. This panel operates on the well known McCulloh principle. Signals are ordinarily received over a closed supervised circuit. With the McCulloh principle, a signal will be received over the circuit even though a single break or a single ground, or both, has occurred on the signaling circuit. This panel automatically adjusts the circuit for these fault conditions instead of the customary switches which are adjusted manually. A break or ground will be immediately indicated by a light and audible signal. The relays used in this panel are very sensitive and will receive signals from a considerable distance on No. 26 gauge wire and longer distances from heavier gauge wire. This panel operates on 24 or 48 volts of D.C. and requires a battery and rectifier for its operation.



Model ACP Single Circuit

Manual fire alarm boxes, automatic sprinkler alarm transmitters, automatic fire alarm, watchman supervisory signals, etc. can be received and recorded on this panel.

BOTH OF THE ABOVE PANELS ARE "APPROVED" BY UNDERWRITERS' LABORATORIES, INC.

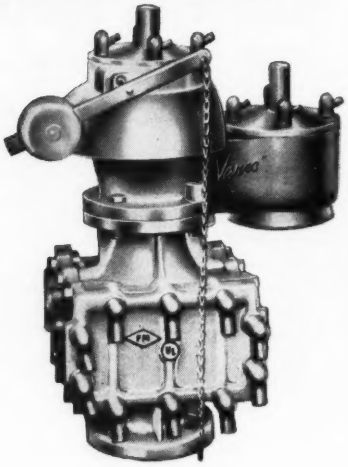
EXTRA SAFETY

at LOW COST...

"Varec"

FLAME ARRESTERS

in combination with your VENT VALVES



Flame Arrester Unit listed by UNDERWRITERS' LABORATORIES Approved by Associated Factory Mutuals Laboratories and other governing agencies.

"Varec" Fig. No. 5800 Vent Unit consisting of "Varec" Conservation Vent Valve in combination with "Varec" Flame Arrester.

The larger area of the multi-plate Flame Arrester bank, greater flow per minute through the Flame Arrester passageways are the "plus" factors to give you extra safety when you install "Varec" Conservation Vent Units. Protection against entry of flame through the venting device is certain when "Varec" Flame Arresters are used. Excessive pressure or vacuum is avoided by use of the "Varec" Vent Valve. The combination unit gives you complete security against the major hazards of flammable liquid storage yet average installation approximately 1/10 of 1% of your investment in tank and product. Consult your nearest "Varec" representatives or write factory.

N.F.-5

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Experienced Reliable Licensees are located throughout the United States, Canada, and foreign countries. They are expertly qualified to design and install a Reliable Sprinkler System for your specific needs.

THE RELIABLE AUTOMATIC SPRINKLER CO. INC.
Manufactured and Distributed by
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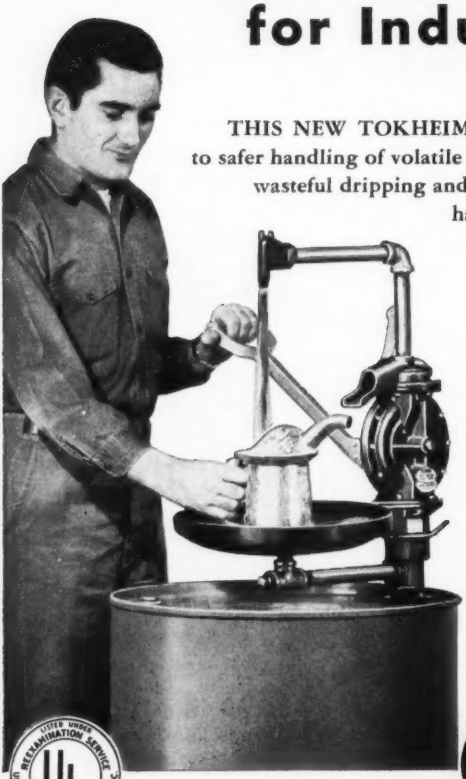
liquid handling for Industry



THIS NEW TOKHEIM HAND PUMP contributes to safer handling of volatile liquids wherever used. Stops wasteful dripping and slippery floors. Reduces fire hazard and accidents common to other methods of liquid transfer. Approved for handling petroleum liquids —ideal for many others. Available in 22 different models for 'most any use— from pipe lines to drums, or underground tanks, with hose or spout outlets. Order from your dealer, your oil company, or your Tokheim representative.

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General Products Division

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UPRIGHT MODEL SSU
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GRIMES SPRINKLERS stand guard over your life and property 24 hours of every day, year after year after year. It is comforting to know they are always dependable and ready to go into action at a minute's notice! Because GRIMES Fire Sprinkler Systems and Equipment are engineered for better protection.

Through the years, GRIMES has earned a reputation for designing, developing and manufacturing the newest and most improved sprinkler equipment available.

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Sprinkler Valve Alarm — Complete Sprinkler Supervisory — Manual Fire Alarm — Automatic Fire Alarm — Temperature Alarm — Oil Burner Supervision — Burglar Alarm — Hold-Up Alarm — Vault & Safe Protection

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CLEVELAND, OHIO	**MORSE SIGNAL DEVICES** **6707 Carnegie Avenue**
DALLAS, TEXAS	**SMITH DETECTIVE AGENCY & NIGHTWATCH SERVICE, INC.** **610 N. Akard Street**
DENVER, COLORADO	**DENVER BURGLAR ALARM COMPANY, INC.** **422-21st Street**
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SO. MINNEAPOLIS, MINN.	**AUTOMATIC ALARM CORP.** **2404 Lyndale Avenue**
WASHINGTON, D. C.	**FEDERAL ENGINERING CO., INC.** **1004 Sixth Street, N.W.**

Armstrong Acoustical Fire Guard provides one-hour rated fire protection for wood construction

Results of latest Underwriters' test open the way for wider use of new Armstrong acoustical ceilings for fire protection.

Early this year, Underwriters' Laboratories Retardant Report #4177-2 announced a *four-hour* rating for a steel deck floor-ceiling assembly utilizing ¾" Armstrong Acoustical Fire Guard acoustical tile. (Acoustical Fire Guard requires no additional fire protection above and in addition to the suspended ceiling.)

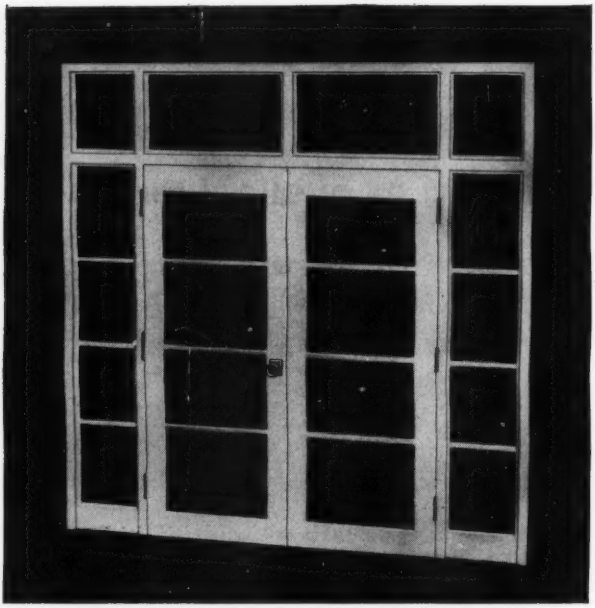
Then Retardant Report #4177-3 announced a *two-hour* rating for steel bar joist assemblies utilizing ⅝" Armstrong Acoustical Fire Guard.

Now a *one-hour* rating has been announced (Retardant Report #4177-4) for a *wood* floor assembly to which ⅝" Armstrong Acoustical Fire Guard was attached.

Inexpensive buildings using wood joists or laminated wood beams can be built at even lower cost by using Armstrong Acoustical Fire Guard to meet time-design construction requirements. Even where time-design-rated construction is not required, Acoustical Fire Guard offers rated fire protection at little or no extra cost over a conventional acoustical ceiling.

For complete information about new Armstrong Acoustical Fire Guard ceilings, contact your nearest Armstrong district office or write to Armstrong Cork Company, 4210 Woodbridge Street, Lancaster, Pennsylvania.

Armstrong ACOUSTICAL CEILINGS

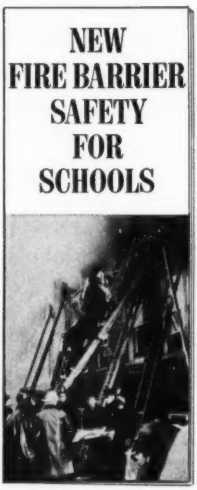


FIRE BARRIERS BY OVERLY ALLOW MORE TIME FOR SAFE EVACUATION

To prevent the disastrous flash spread of fire, Overly has developed and obtained UL approval on a unique smoke screen fire door and frame assembly. Used to subdivide long corridors and enclose stairwells, the Overly smoke screen will bar the progress of fire, smoke and heat for a minimum of 45 minutes — more than ample time to permit safe exit.

Get the graphically illustrated story of how adequate fire barrier protection in your schools can save lives. Send for a free copy of the folder shown at right. Write us today.

■ A new eight-minute color film—Fire Barriers by Overly—is available for group showings. We shall be happy to arrange a presentation.



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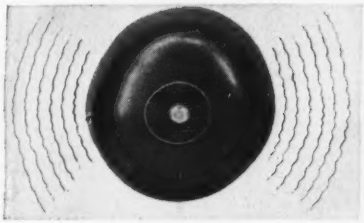
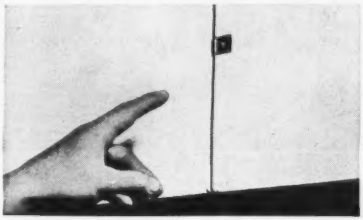
FIRE ALARM!



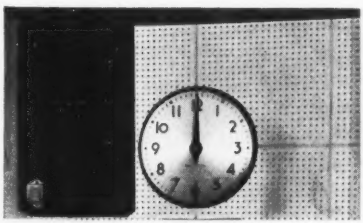
1. Save priceless lives, protect valuable buildings with the Kidde Atmo Fire Detecting and Alarm System!

2. This automatic detecting and warning system sounds an alarm instantly at the *first* hot breath of fire!



3. Using rate-of-temperature-rise tubing as a sensing element, the system works without outside power!

4. Kidde's Atmo system can sound alarm at fire area, outside the building or at local fire department station!



5. Kidde's Atmo system also gives fire location at a panel near any manned telephone switchboard!

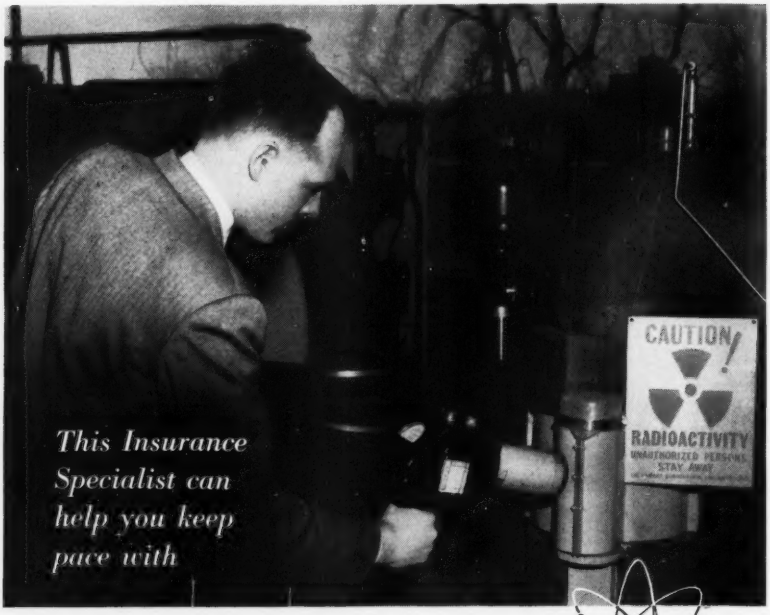
Kidde Atmo

KIDDE ULTRASONIC & DETECTION ALARMS, INC.

1051 Brighton Road, Clifton, N. J.

A Subsidiary of
Walter Kidde & Company, Inc.
Belleville 9, N. J.

FOR fast, dependable fire detection and warning, install a Kidde Atmo Fire Alarm System. Ideal where life protection and early fire warning is essential, the Kidde Atmo system can also close doors, shut off fans, motors, blowers, is automatically re-setting after use or test. Get more information! Write today and ask for Kidde's Atmo Alarm Systems booklet!



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With the advance of the Nuclear Age, users of radioactive materials have greatly increased in number and are present in nearly every community.

As a result, there is a growing need for highly specialized insurance protection against the hazards of radioactive contamination. Ætna Casualty is a leader in this brand new and rapidly expanding field.

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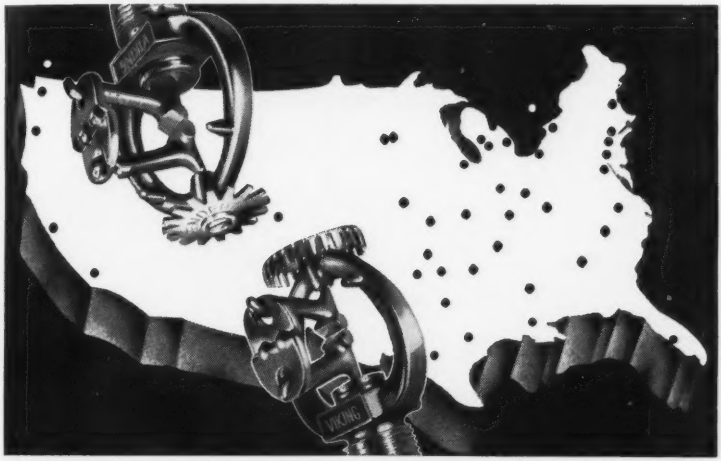

VIKING FIRE PROTECTION

For fire control whatever it happens to be, call the nearest Viking Representative

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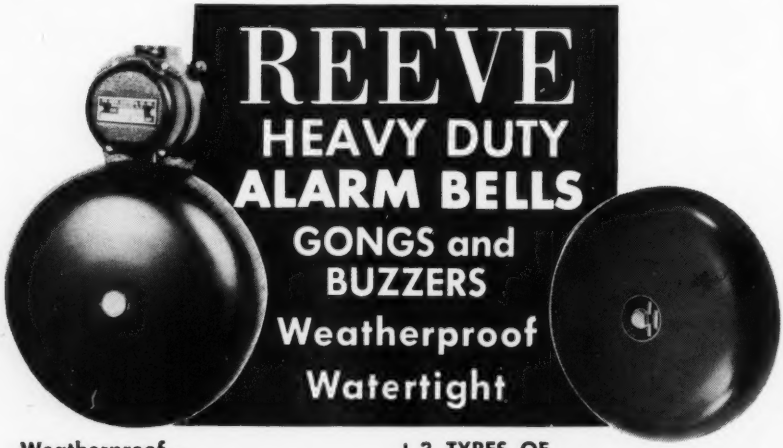

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Sizes 3", 4", 6", 8", 10", 12"
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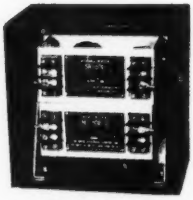
The unit is designed for use on any storage batteries not subject to heavy drains. It will trickle charge the battery indefinitely because of its automatically decreasing rate of charge.

For use with six cells (12 volts). Automatically controlled by saturable reactor. Continuous output one ampere. 22.5 watts, 118 volts, 60 cycles. 3% Regulation. 9" x 9" x 6" — 14 B & S gauge steel wall cabinet. 15¼ lbs. U.L. Approved. No moving parts.



MODEL BC-12

Manufacturers of a complete line of
CENTRAL OFFICE and LOCAL FIRE ALARM DEVICES
· automatic alarm devices · sprinkler alarm and supervisory devices · burglar alarm devices and accessories. DYNALARM (sound detection for both reverberant and non-reverberant vaults).

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New, all wood office building—accepted as non-combustible. NON-COM pressure-treated wood was used for all structural and interior wood members. Sprinklers were not required.

NON-COM FIRE PROTECTED LUMBER

A new, non-combustible building material that automatically provides superior resistance to both fire and flame spread.

NON-COM treated lumber is the first truly non-combustible wood offered for building. The superior performance of NON-COM lumber results from a new formulation of fire-protecting chemicals pressure-impregnated into the cells of the wood. When fire threatens, the NON-COM chemicals in the wood react as catalyzers and produce instant and continuous protection to retard the spread of fire through or along the wood surfaces.

NON-COM lumber and plywood have been used to meet these "incombustible" requirements: roof support and decking, wall studs, trim and finish and framing.

Non-Com fire protected lumber is UL listed with a Fire Hazard Classification Rating of 10-15; approved by Factory Mutual Engineering Division and Factory Insurance Association as a basically incombustible material; classified as an incombustible roof deck material by 17 Mid-western Rating Bureaus.

Write for Bulletin W-365 which gives the details about NON-COM wood, its specifications, approvals.

Koppers Co., Inc., Wood Preserving Division
781 Koppers Building, Pittsburgh 19, Pa.

G-29

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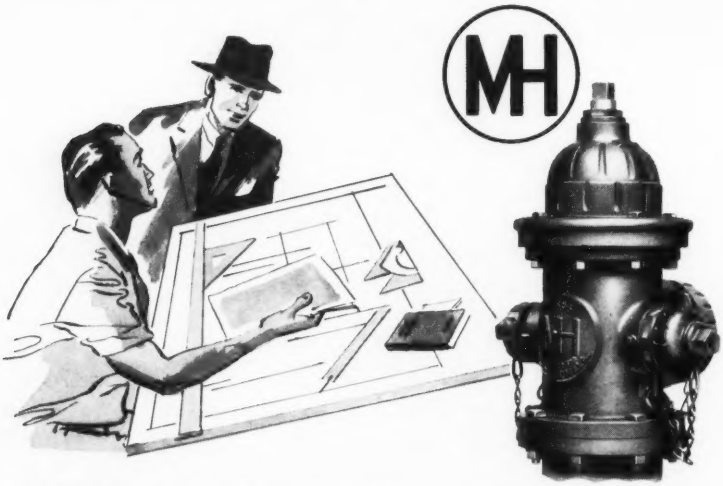
NON-COM FIRE-PROTECTED LUMBER



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We have gratefully accepted their contributions, which we have tested through years of research in engineering, design and foundry practice. The result is that M & H valves and hydrants are now widely known for their easy, practical and dependable service year after year.

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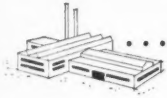

. . . protect lives and property

. . . cut insurance cost

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Fire in any building you manage — commercial, industrial or institutional — may result in losses which cannot be replaced.

You can avoid these losses — and make additional savings — by installing Rockwood Sprinklers.

Over 18 million Rockwood Water-FOG Sprinkler Heads have been installed for the protection of thousands of buildings, hundreds of thousands of lives and millions of dollars worth of property. Their proved efficiency is recognized by fire insurance companies, which grant substantial reductions in premium rates on all properties equipped with them. Another money-saving advantage is the elimination, in many communities, of fire doors, fire walls and other additions required in new construction, particularly in public buildings.

Rockwood can engineer a complete fire protection system to meet your particular needs and to handle any special fire hazards. The savings it brings you will be as continuous and sure as its protection. Out of premium reductions alone, your entire installation may pay for itself. And your working capital can be protected by deferred payments. Tested and listed by Underwriters' Laboratories, Inc. For further facts, write to Rockwood Sprinkler Company, 3004 Harlow St., Worcester 5, Massachusetts.

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A Division of the Gamewell Company

Engineers Water . . . to Cut Fire Losses

Branch Offices in all principal cities

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it's almost certain one or more of the dependable, high-quality fire fighting products... known by these famous brands... will be called upon to fight the fire!

Consolidated under a single organization, these brands comprise the most complete line of competitively-priced fire protection products and services ever offered. This means you can guard against every fire risk by contacting a single source for all these products: approved fire extinguishers; automatic sprinkler systems; carbon dioxide, dry chemical and foam systems; fire hose, nozzles and couplings; alarm systems; and fire department accessories including ladders, sirens, clothing, breathing apparatus, first aid kits, etc.

Representatives of this broad product line, with their depth of knowledge and experience in all industrial, commercial, institutional, municipal and household fire hazards, are uniquely qualified to *survey, analyze* and *recommend the proper equipment* for every fire protection requirement. To contact the representative nearest you, look in the yellow pages under "Fire Protection Equipment" or write to:

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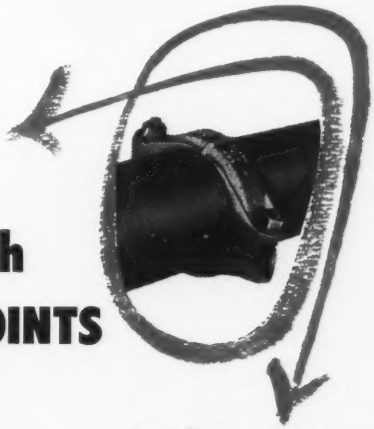
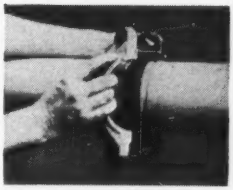
Couple Pipe the Easy, Low Cost Way with New G-B GRUVAJOINTS



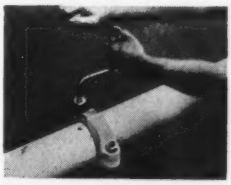
Now you can save up to 25% when connecting pipe for bulk runs and risers. Yes, contractors are saving money every day when they use new lightweight Gruvajoints. There's no flanging, no threading, no welding, and there's no need for heavy chain tongs or pipe wrenches. Gruvajoints are truly the modern way to couple pipe. Write today for free illustrated brochure on G-B Pipe Coupling Products. Gruvajoints are now available in 2", 2½", 3", 4", 5", 6" and 8" sizes.

Install Gruvajoints in three easy steps

Grease gasket and center over pipe ends.



Lay housing halves into grooves and insert bolts.



Tighten the two nuts equally.

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Factory Mutual Engineering Division
Report Serial No. 13097

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MODEL HT
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now listed by
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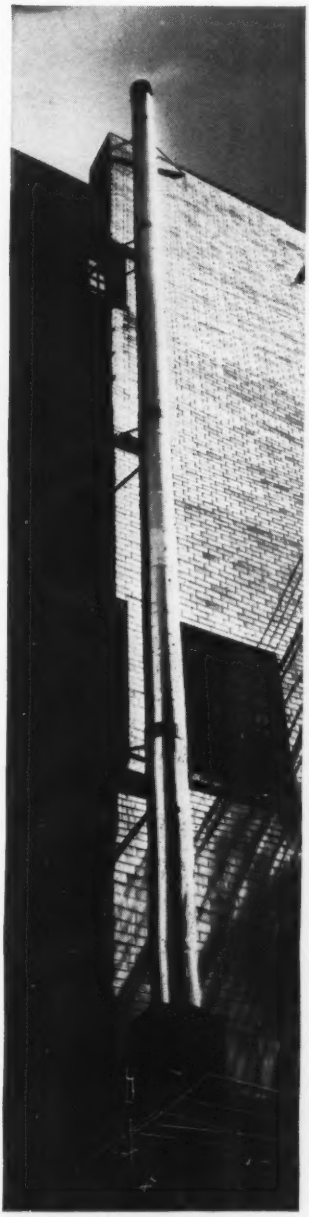

Wherever you see a Van-Packer Model HT Prefabricated Refractory Smokestack specified for boilers, furnaces and incinerators, you can be sure it will give safe and reliable service. Van-Packer Model HT Smokestacks meet the high standards required to earn listing by Underwriters' Laboratories, Inc.

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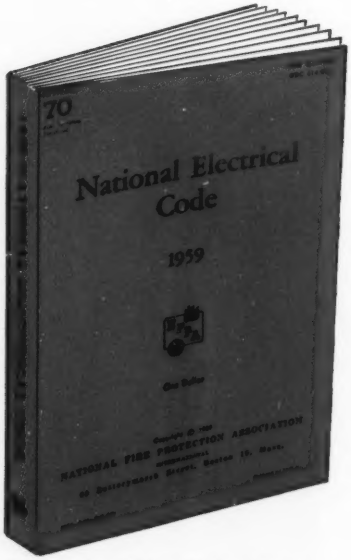

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For Sprinkler Systems

Kuhns ductile iron pipe fittings—the newest development in piping—provide an extra margin of operating safety for sprinklers, high pressure lines and other vital piping systems. High structural strength and resistance to thermal shock help these fittings prevent leakage caused by vibration, temperature changes or misalignment.

"K" Pipe Lock Couplings

Listed for 800 psi by Underwriters' Laboratories, Inc., these couplings have a safety factor of five times the UL listing for 2½" through 6" and four times UL listing for 8". Sizes: 2½" through 8". Look for the "800 D" on each.

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¼" to 3" ..... 300 lbs.

LIQUID AND GAS AT 150°F

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**Ductile iron fittings are available in any size in Kuhns complete cast iron line, ¼" through 12".*

Note: These fittings are excellent for liquefied petroleum gas systems. Look for the "DI 300" on each.

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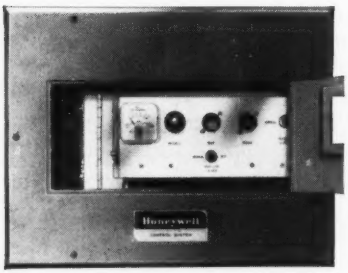
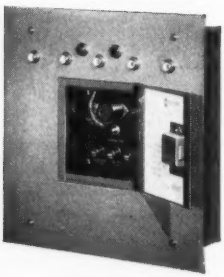
For COMPLETE Protection...

Honeywell's Line of Automatic Fire Detection and Alarm Systems

For the most up-to-date fire protection, choose a Honeywell automatic fire alarm system. The Honeywell panels shown are typical of the many available. They provide the ultimate in personnel evacuation and property protection. To complete your system Honeywell offers a full line of automatic detectors, manual pull stations, horns, gongs, buzzers and related equipment. All are U.L. approved, and backed by fast, efficient Honeywell service and maintenance. For more information phone your nearest Honeywell office or write Minneapolis-Honeywell, Dept. QN-10-65, Minneapolis, Minnesota.



W247 Panel for the ultimate in detection and alarm for safe evacuation in buildings of all sizes. The panel features large bell capacity—up to 5 bell circuits operating a total of up to 50 bells. Choose from 3 types of alarms: *continuous ringing*, *master coded* and *selective coded* (bells ring in code to identify fire location). This panel features supervision of both the detection and alarm circuits.



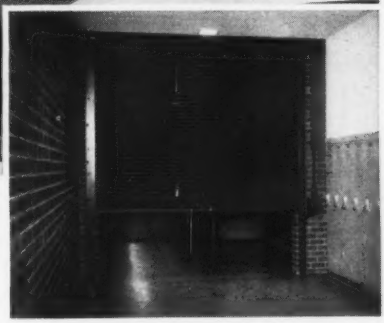
W237 Panel for maximum protection of property and the ultimate in fire alarm reliability. Available with standby battery operation so alarm will sound even during a power interruption. This system is designed so that it can sound the fire alarm even with a break or ground in the detector wiring.

The detection circuit is completely supervised, and two independent alarm circuits are provided. Numbered lights on the panel quickly and positively indicate the fire location. Both detection and alarm circuits are low voltage.

Honeywell

H HONEYWELL First in Control

MODERN FIRE PROTECTION



Kinnear Rolling Fire Doors

This striking new high school at Kellogg, Idaho, presents architectural progress at its best. Right at home in this modern setting are six Kinnear Rolling Fire Doors, like the one at right — with the interlocking steel-slat curtain originated *by Kinnear* nearly 60 years ago. Like the school itself, these doors owe much of their eye appeal to basic, functional efficiency. In case of fire, they lower *automatically*, blocking the spread of flames. Positive, spring action starts them, yet downward speed is *controlled* for safety. And they can be opened after automatic closure, if necessary. For extra fire protection plus highest safety for building occupants install Kinnear "AKBAR" Rolling Fire Doors (labeled by Underwriters' Laboratories, Inc.)

For all regular (non-fire) needs, standard Kinnear Rolling Doors save space, time, and cut costs. They give added protection against fire, wind, weather, trespass, and vandalism. Built any size; motor or manual control.

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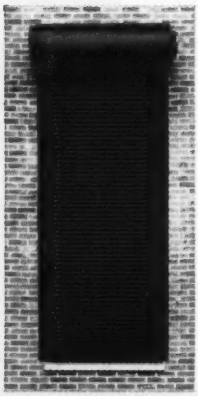
Saving Ways in Doorways

Automatic Rolling Steel
FIRE DOORS *and* WINDOW SHUTTERS
PREVENT SPREAD *of* FIRE!



You need good automatic fire doors in fire walls, corridors, and vertical shafts . . . in some cases automatic rolling steel window shutters are necessary to protect your building and its contents from fires which may originate in nearby buildings. Many, many cases are on file which confirm that timely action of automatic rolling steel fire doors and window shutters have confined a fire to its point of origin and permitted its being extinguished with comparatively small damage. Make a survey of your building now, and don't delay action. You will find a Mahon Automatic Rolling Steel Fire Door or Window Shutter to meet each of your requirements—all bear the Underwriters' Label. These automatic fire doors may be operated manually or mechanically in every day use. If a fire should break out while they are in the open position, the automatic mechanism will close the door, cutting off drafts and preventing the spread of the fire. See Sweet's Files for complete information, or write for Catalog G-60.

THE R. C. MAHON COMPANY • Detroit 34, Michigan

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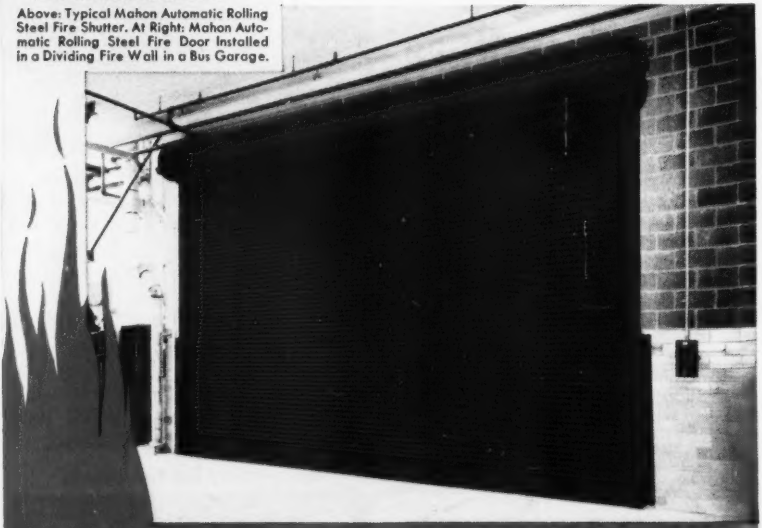
Manufacturers of Standard and Underwriters' Labeled Automatic Rolling Steel Fire Doors and Window Shutters; Underwriters' Rated Metalclad Fire Walls; Insulated Metal Curtain Walls; Electrified M-Floors; Steel Roof Decks; Acoustical Long Span M-Decks; and Acoustical and Troffer Forms.

Above: Typical Mahon Automatic Rolling Steel Fire Shutter. At Right: Mahon Automatic Rolling Steel Fire Door Installed in a Dividing Fire Wall in a Bus Garage.



MAHON ROLLING STEEL FIRE DOORS and WINDOW SHUTTERS

NOTIFIER

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NEW N-CO-BELL®

Underwriters' Laboratory Listed

CREATED with IMAGINATION not IMITATION

• SUPERIOR • DIFFERENT • COMPELLING

N-Co-Bell's controlled stroke provides superior gong vibration producing a distinctive and arresting sound. An unusually low amperage drain permits the use of 2 or 3 times as many bells per ringing circuit as other bells.

CONSIDER THESE FACTS - - -

- The 6 volts D.C. Bell draws only 0.14 ampere
- The 12 volts D.C. Bell draws only 0.07 ampere
- As many as 25 N-Co-Bells can be rung at less than 2 amps 12 volts D.C. at the power source.

CHARACTERISTICS

All N-Co-Bells are underdome with handy-mount features
Either pig-tail or plug-in wiring connections
Simple but effective "O" ring weather-proofing
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Sizes 6-8-10 and 12 inch
All size gongs interchangeable
Numerous models—all available for quick delivery
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Underwriters' Laboratories listed for both fire protection and electrical use.

N-CO-BELLS mean ECONOMY

You pay no more for a QUALITY N-CO-BELL than an ordinary bell.

Compare our prices with other high quality bells.

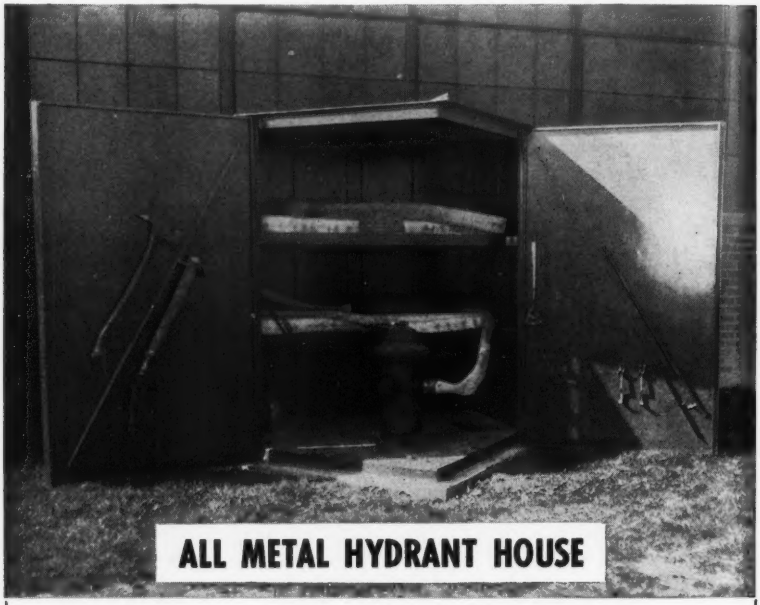
No extra charge for distinctive sound performance.

Write for particulars * * * Order your sample

NOTIFIER CORPORATION

3700 North 56th St. Lincoln, Nebraska

NOTIFIER FIRE ALARM



— FACTORY MUTUALS APPROVED —

Many Architects and Engineers are specifying the Model 60 or 60-L ALL-METAL Hydrant House on new jobs and recommend their use for replacement of existing wooden houses as they wear out.

The advantage of a Hydrant House is that it protects the hose and hydrant during inclement weather when sleet or snow cause heavy icing. The hose is coupled and ready at any hour of the day or night. All metal houses are weathertight and rat proof — will not warp or dry out. Eight (8) Louvers are stamped in side panels and shelves are perforated for ventilation. Finished weights — 565 lbs. and 650 lbs.

Houses are shipped from stock, knocked down. Roof, base, shelves, doors and panels are completely prefabricated of **galvanized iron with zinc plated hardware. Hinges are brass pinned.** All bolts for assembly are furnished. No cutting, drilling or welding is required in the field, thereby reducing the installation time to a minimum. Instructions are furnished for a simplified concrete foundation slab.

Manufactured by

VAN LOON INDUSTRIES, INC.

ENGINEERING & METAL FABRICATING

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TWinbrook 3-4460 TWinbrook 3-4461

PREFABRICATED METAL HOUSES FOR HOSE CARTS

IMPORTANT NEWS
for you about
Fire Protection

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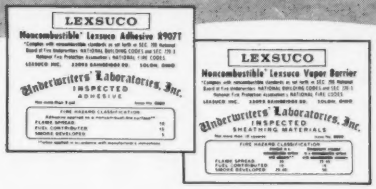
Test and Accept
LEXSUCO
ROOF CONSTRUCTION MATERIALS



Underwriters' Labels identify Lexsuco Vapor Barrier and Lexsuco Adhesive R907T—the only products of their kind to bear this well known label.

Noncombustible Standard met by Lexsuco Vapor Barrier and Lexsuco Adhesive R907T. Underwriters' Label granted.

● Underwriters' Laboratories, for the first time, has tested and accepted a roof vapor barrier and adhesive. Extensive tests proved that the Lexsuco Vapor Barrier and Lexsuco Adhesive R907T meet the noncombustible standards established by the National Fire Protection Association and the National Board of Fire Underwriters.

Assured Fire Protection. With or without a vapor barrier, the Lexsuco system completely eliminates combustible asphaltic materials between the roof deck and roof insulation. When you specify Lexsuco Adhesive R907T with the Lexsuco Vapor Barrier, or the adhesive only, over metal roof deck, you get assured building fire protection.

More for Your Roofing Dollar. Lexsuco products give you far more value for the money you invest. When you put Lexsuco products in your base specifications, subject to competitive bidding, you pay little or *no* more for the extra protection and value of these noncombustible materials than you would for combustible materials.

Lower Insurance Premiums. With Lexsuco roof constructions you may receive lower insurance rates, and this is a *permanent* saving, repeated year after year. Both Underwriters' and Factory Mutual have tested and accepted the Lexsuco materials. Lexsuco Roof Constructions are also recognized by Factory Insurance Association and many State Rating and Inspection Bureaus. Investigate possible insurance savings on all your projects.

Engineered Application. By removing much of the human element the Lexsuco system of engineered mechanical application assures a more thorough, uniform application and more dependable construction.

Better Roof Construction. On *all* roof decks — metal, poured, precast or wood — you get economical and dependable securement with Lexsuco Adhesive R907T. Where it is necessary to protect the insulated, built-up roof from moisture migration from within the building, you get proven protection with the Lexsuco Vapor Barrier.

Write us for complete information and the Underwriters' Report on Lexsuco Products.

LEXSUCO INC
BOX 336 • SOLON, OHIO
Noncombustible Roof Constructions and Waterstops

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GIVES YOU MORE — FOUR WAYS

UPRIGHT SPRAY SPRINKLER

PENDENT SPRAY SPRINKLER

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SMALL ORIFICE SPRINKLER
(With Identifying Pintle)

1 **SUPERIOR PROTECTION** . . . due to more efficient water distribution. Proven by tests under actual fire conditions for all classes of hazards.

2 **MORE EFFECTIVE USE OF LESS WATER** . . . because wider distribution and break-up of the water discharged provides greater cooling and extinguishment.

3 **CEILING PROTECTION BY COOLING — NOT WETTING** . . . All the water goes onto the fire. The break-up of water results in complete cooling and control of flammable vapors.

4 **MORE FIRE CONTROL WITH FEWER SPRINKLERS** . . . because ceiling temperatures are kept lower, fewer sprinklers open. Immediate water saturation of the fire area prevents the spread of fire. Hot gases become impotent in the cooled atmosphere.

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VICTAULIC COUPLINGS

Styles 77, 77-D for standard applications. Simple, fast to install — sturdy and reliable. Sizes ¾" to 30". Style 75 Light-Weight Couplings for light-duty applications. Sizes 2" to 8". Additional styles for cast iron, plastic and other pipes. Sizes through 60".

ROUST-A-BOUT COUPLINGS

Style 99 for plain or beveled end pipe. Best engineered, most useful plain end joint on the market. Simple, husky — easy and fast to install. Takes strong bull-dog grip on pipe. Sizes 2" to 12".

VICTAULIC FULL-FLOW FITTINGS

Complete line of Elbows, Tees, Reducers, Laterals, etc. — to fit all Victaulic Couplings. Streamlined for top efficiency, easy to install. Sizes ¾" to 12".

VIC-GROOVER TOOLS

Handy, on-the-job grooving tools that do the job in half the time. Light weight, easy to handle — operate manually or from any power drive. Automatic groove position and depth. Sizes ¾" to 8".

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Underwriters' Laboratories, Inc.
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New York City Board of Standards and Appeals, Cal. #413-53-SM.

Proven for 28 years on both wet and dry Fire Protection Systems. Standard with most major sprinkler companies for bulk-run and cut-in piping. Victaulic Couplings are installed in *less than one-half the time* required for other standard pipe joints.

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VICTAULIC

COMPANY OF AMERICA
P.O. Box 509, Elizabeth, N. J.

RELIABLE METALBESTOS GAS VENT PIPE

SCIENTIFICALLY INSTALLED

The METALBESTOS "Safety Seal" is your assurance that the gas venting system is correct. It is used by better dealers to show that the system has been installed according to the METALBESTOS "Safety System" Gas Vent Tables. These tables are an industry standard and give clear, accurate data on correct sizes, lengths and connections to provide proper design and installation of a safe and efficient venting system.

SCIENTIFICALLY DESIGNED

- Listed by Underwriters' Laboratories, Inc.
- Durable, practical construction and materials.
- Tested for all conditions and uses.
- Available in all areas.

If you would like a copy of the "Safety System" Gas Vent Tables, write to Dept. T-10.

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Manufacturing Plants in Belmont, Calif. • Logan, Ohio • Brockville, Ontario, Canada

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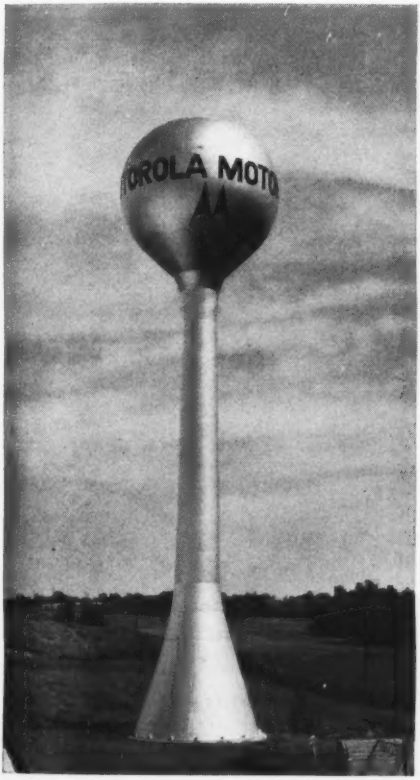
• • • helps plant save 80% on insurance



At the Quincy, Illinois, plant of Motorola, Incorporated, an 80 per cent insurance premium reduction was realized through the installation of a sprinkler system and a Watersphere. The savings earned through lower insurance premiums will pay for this fire protection system in approximately six years.

The Horton Watersphere has a capacity of 100,000 gallons and a height to the bottom capacity line of 100 feet. It provides a source of water supply to supplement the city mains. The sprinkler system is composed of 1,632 sprinkler heads and protects a building area of 183,000 square feet.

Motorola's Quincy plant was established in 1948, and is one of the Company's nine manufacturing plants. Home, portable, clock and automobile radios and phonographs are manufactured at the Quincy plant.

Waterspheres are available in capacities from 25,000 to 250,000 gallons. In addition ellipsoidal bottom elevated tanks in capacities from 15,000 to 500,000 gallons are also available.

CHICAGO BRIDGE & IRON COMPANY

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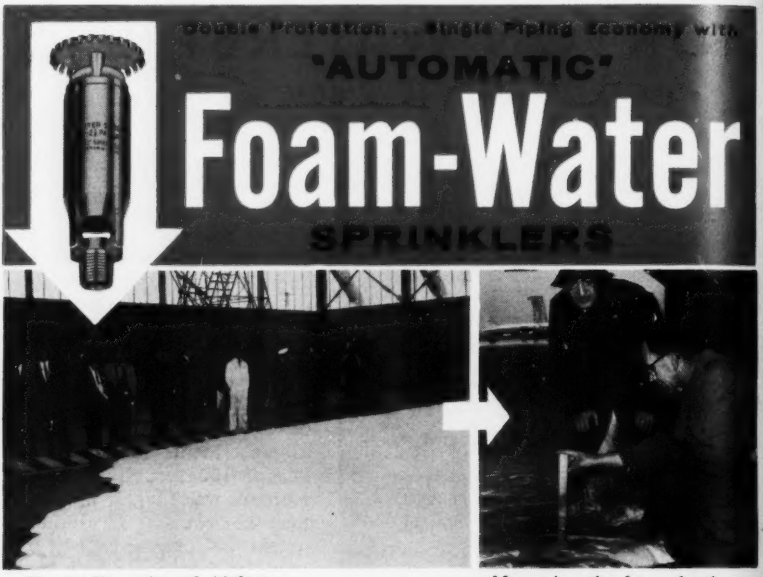
Plants at Chicago, Birmingham, Salt Lake City, New Castle, Del., Houston, Tex. and Greenville, Pa.



The leading edge of Airfoam beyond system discharge.

Measuring the foam depth at Canadian Pacific Airlines hangar, Vancouver, B. C.

FOAM-WATER Sprinkler Systems function like a deluge system by spraying foam from sprinkler heads, thus reducing structural temperatures as the foam blankets the floor. Fires caused by leaking or spilled flammable liquids are smothered and combustion at floor level is prevented from spreading.

This system automatically changes from foam to water discharge when the foam supply is exhausted and can be changed manually to water at any time. Generally, no re-design of piping is required to adapt FOAM-WATER to existing deluge sprinkler systems.

The FOAM-WATER sprinkler system is a product of "Automatic" Sprinkler's industry-leading research laboratories . . . also pioneers in

- **Rate-of-Rise**
- **Hydraulically-designed Sprinkler Systems**
- **Fire Fog Systems**
- **Deluge Systems for Aircraft Hangars**
- **High Speed Fire-Fog**
- **Automatic Fixed-Pipe Dry Chemical Systems**

Write for Bulletin 73 or contact your local "Automatic" Sprinkler representative for the ***complete fire protection assistance*** *that only three-quarters of a century leadership can offer.*

"Automatic" Sprinkler

"AUTOMATIC" SPRINKLER CORPORATION OF AMERICA
YOUNGSTOWN, OHIO
OFFICES IN PRINCIPAL CITIES OF NORTH AND SOUTH AMERICA

His community showed the way . . .

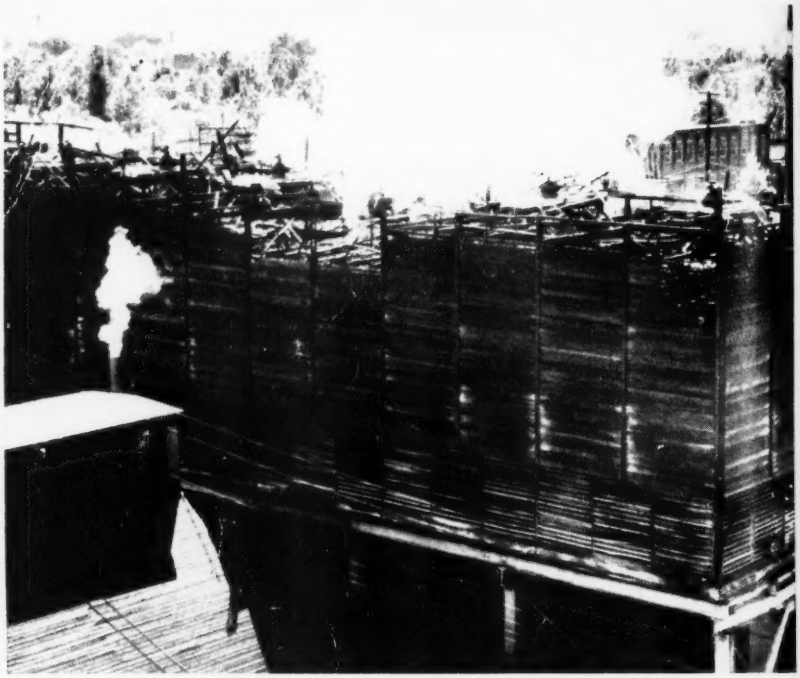
Chief Thomas F. Gorman of Quincy, Massachusetts, knows that his city will continue to have positive, adequate, fire protection facilities. Recently, Quincy became the first municipality to pass an ordinance requiring that all new residential and institutional construction have fire detection and alarm facilities within its confines.

Quincy's Gamewell Fire Alarm System protects all residential and high value areas through strategically located curb boxes. Master Boxes tie all hospitals, public schools, and a great many larger industrial buildings into the municipal system. Seconds after any box is pulled, Quincy's entire fire defenses, as well as police and waterworks, know its location.

Is *your* city this well protected? Gamewell will be happy to supply copies of the Quincy ordinance and conduct a fire survey to assist you in planning *better* fire protection. Write The Gamewell Company, Dept. 4E, Newton Upper Falls 64, Massachusetts.

Gamewell®

FIRST...WHEN SECONDS COUNT



Fire caused by friction spark destroyed top 6 feet of this cooling tower, damaging motors, shafts, gear boxes.

Protect water cooling towers from crippling fire with a Grinnell System!

Why are cooling towers so vulnerable to fire? Because they are largely made of wood. It is true that when the tower is operating, most of the wood is wet. But roof and sides can become excessively dry through exposure to the sun. Also, there is a portion of the tower above the cooling water distribution system that is never wet. Common causes of fire include defective wiring, overheated bearings, and lightning.

Moreover, fire may strike when the tower not only is shut down, *but even while it is in use*. One insurance company has stated that nearly half its losses involving towers occurred when they were in operation!

The wise protection against an unexpected blaze in water towers is a Grinnell Water Spray or Automatic Sprinkler System, engineered by Grinnell to protect against fire, no matter how it may start. Grinnell engineers are well qualified . . . backed by a company with 89 years experience in the fire protection field. For complete information, write Grinnell Company, 260 West Exchange Street, Providence 1, Rhode Island.

GRINNELL

FIRE PROTECTION SYSTEMS SINCE 1870